Constitutional Study

ENVIRONMENTAL MANAGEMENT

by

J.W. MacNeill

Prepared for the

Government of Canada

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FOREWORD

At an early stage in the constitutional review, the federal government concluded that in studying the distribution of powers careful attention would need to be given to environmental management. This is a large and complex field. It involves many areas of responsibility of each order of government. Existing constitutional arrangements do not provide clear guidelines concerning the roles and responsibilities of the respective governments in relation to it.

Mr. J.W. MacNeill, at that time the Director of the Policy and Planning Branch, Department of Energy, Mines and Resources, was seconded to the Privy Council Office in order to work in this field. Mr. MacNeill was asked to provide a background of information and analysis, against which federal proposals regarding constitutional powers related to environmental management could be developed and discussed in the course of the constitutional review.

This study by Mr. MacNeill is one result of his work. The views expressed by Mr. MacNeill concerning environmental problems and their implications are his own, and are not intended to suggest any position on the part of the federal government. The study is thus fundamentally different from the series of working papers so far published by the federal government, which contain tentative constitutional proposals of the government.

It is hoped that Mr. MacNeill's study will be of value not only to the federal and provincial governments, but also to the Joint Committee of the Senate and House of Commons on the Constitution of Canada and to others, as background information and analysis concerning a subject that is of such lively interest to Canadians. It is now being made available in published form to assist consideration of environmental management in the constitutional review.

Ottawa, January 1971

PREFACE

This study appears at a time when intense public concern about the quality of life is prompting a revaluation of traditional attitudes and responses in many areas of public policy, including that of environmental management. Man, with his economic power and dynamic technology, seems to be threatening different parts of the biosystem with increasing frequency. All governments are becoming increasingly aware of the seriousness of this problem and are modifying their goals and priorities, and adopting more effective means to halt the deterioration of the natural environment and to enhance its future quality.

The development and application of environmental strategies in Canada is frequently affected by constitutional uncertainty. In June, 1969, the Constitutional Review Section of the Privy Council Office initiated work in this area and I was asked to design and undertake this work.

This study was conceived with a twofold purpose: first to examine some of the present and possible future dimensions of environmental management; and, second, to identify the range of strategies that governments may need to employ, and that a constitution should permit them to employ, at the urban, provincial, national and international levels. Since the concern is with a constitution for tomorrow, the focus is on the basic trends underlying environmental problems as they now exist and as they could develop over the next few decades. I have attempted to identify some of the major, emerging problem areas and to draw out characteristics that appear especially relevant to constitutional arrangements. I have also considered the range of strategies that governments may need to employ, and discussed factors relevant to the determination of the appropriate roles of different orders of government in environmental management.

The study, however, is not a blueprint for action; it is not a document on how the environment should be managed. It does not evaluate the relative effectiveness of different strategies. It does not propose particular policies or programs to deal with specific current problems. Any attempt to do so would have been inappropriate considering the purpose, scope and time horizon of the study. The relative effectiveness of strategies and programs not only can vary significantly with the specific problem, but also can change greatly with time. Moreover, current problems will have to be resolved largely by strategies adapted to and applied within the existing jurisdictional and institutional framework.

In a sense, this is three studies in one. It deals with environmental management in our urban regions, in our rural and territorial areas, and in our atmosphere and waters. It is, however, tied into a single whole by its global

ecological perspective, by its common framework of definitions, concepts, and methodology, and by the broad demographic, economic and technological trends presented in the first two parts. Each part relies heavily on the analysis presented in the preceding parts and the study should therefore be read consecutively.

The study is future oriented and, therefore, demographic, economic and other projections are used throughout. I must stress that these projections are *indicative*; they are not *predictive*. It is vital that this point be appreciated at the outset. The projections are employed to deduce the possible shape of future environmental problems. They indicate what *might* happen if existing trends continue. They do not purport to predict what will happen. Some of the indicated "futures" will appear desirable, others undesirable; but none of them is inevitable. Within limits that increase with lead-time, they are subject to modification by public policy.

The study has a number of limitations, and I hope that they will be the subject of comment and criticism. I should like to comment briefly on two of them.

First, the study does not take into account the massive social, cultural and other changes that are occurring and that will have a significant, perhaps a crucial, impact on the outcome of environmental issues. To have done so would have been to assume an unattainable understanding of these changes, requiring techniques of projection and analysis as yet unknown. It would also have led towards a holistic analysis of contemporary and future society beyond the purpose and scope of the study. While the basic trends identified can be used to analyze a whole spectrum of public policy issues, the study uses them simply as a framework within which to identify and assess emerging problems of the natural environment and to indicate the appropriate roles of different orders of government in dealing with these problems.

Second, the study gives considerable attention to the side effects and costs of economic growth. This, too, stems from its purpose and should not be taken to imply a conviction on my part that economic growth is incompatible with environmental quality. On the contrary, I believe that the basic goals of economic growth and environmental management are the same, a better quality of life for mankind. I also believe that both are required to achieve it. In the past, the benefits of economic growth have, in my view, far exceeded the cost. In the future, the benefits of growth can provide the means to finance the strategies required to enhance environmental quality. This assumes, of course, that a greater proportion of the nation's product will be allocated to environmental management measures. It also assumes a greater degree of social guidance of research and technology. Effective environmental management strategies in the future must reconcile economic growth with a progressively improving level of environmental quality. A major theme of the study is that this can be facilitated by a flexible division of powers that enables each order of government to play its appropriate and constantly changing role.

This study would not have been possible without access to the existing body of literature and information on or related to environmental management. The literature on Canadian environmental management is not yet very extensive, however, and I found it necessary to contract a number of special studies. I would like to mention three of these.

Professor Dale Gibson's special study *Constitutional Jurisdiction over Environmental Management in Canada* enabled me to understand some of the complexities of our existing legal framework in this area. It also made it unnecessary for me to attempt an extensive treatment of our present constitutional arrangements. I should add that I am not a member of the legal profession and that my comments on possible constitutional provisions are advanced with considerable deference.

Dr. C. Ian Jackson's special study *The Spatial Dimensions of Environmental Management in Canada* provided insights on the geographical aspects of environmental management and on the possible dimensions and implications of transboundary spillovers. The four special studies undertaken by the Systems Research Group provided my main source of demographic, economic, transportation and housing projections. They are cited extensively throughout the study.

The preparation of this study has been a most interesting assignment. I hope that it will be useful to the federal and provincial governments in their review of the constitution as it relates to this subject, and that it will contribute to the continuing public discussion of this important matter.

J.W. MacNeill,
January 4, 1971.
Ottawa, Canada

ACKNOWLEDGEMENTS

A large number of people have been of invaluable assistance to me during the preparation of this study and I am happy to acknowledge my indebtedness to them.

For their valuable advice, assistance and support, I would like to give special thanks to R.G. Robertson, Clerk of the Privy Council; R.B. Bryce, Economic Advisor to the Prime Minister on the Constitution; A.W. Johnson, Secretary of the Treasury Board; E. Gallant, Deputy Secretary to the Cabinet (Federal-Provincial Relations); and B.L. Strayer, Director of the Constitutional Review Section, Privy Council Office. I wish also to express my appreciation to C.M. Isbister, former Deputy Minister, and A.T. Davidson, Assistant Deputy Minister (Water), Department of Energy, Mines and Resources whose co-operation and support made it possible for me to undertake this assignment.

Throughout the study I have relied heavily on work undertaken by Professor R.W. Judy of the University of Toronto and his associates in the Systems Research Group. Professor P. Oberlander of the University of British Columbia provided written and oral information as did Professor Hans Blumenfeld of the University of Toronto; A. Armstrong, Executive Officer, Canadian Council on Urban and Regional Research; R.G. Adamson, Executive Director, Central Mortgage and Housing Corporation; and W.A. Scotland, Chief Engineer, National Energy Board. I am also grateful to officials of various departments and agencies who have directed relevant information my way and who have read the manuscript and offered their comments and suggestions.

I owe a special debt to Professor N.H. Lithwick of Carleton University and W.M. Baker, Recreation Consultant, Toronto, from whose works I have derived ideas and information. Professor R.D. Gibson of the University of Manitoba has facilitated this work from its inception in numerous ways and Dr. C. Ian Jackson, Chief of the Economic Geography Section, Department of Energy, Mines and Resources, has provided advice, assistance and support throughout the entire period of research, writing, review and editing.

I am also grateful to many persons who assisted in the preparation of the manuscript: G. Frazer, who made many of the necessary arrangements; Miss Julie Loranger, who supervised the preparation of the French edition; D.E. Spring, who looked after the footnotes and manuscript preparation; the staff of the Constitutional Review Section, who rallied around on a number of occasions to meet production deadlines; the drafting and other personnel of the Economic Geography Section, who produced the maps and figures; and to my secretary, Mrs. Adela Bradley, whose skill and equanimity never failed.

I must acknowledge a special debt to Nicholas Ignatieff. He acted as my assistant throughout, co-ordinating studies, compiling information, directing production and assuming responsibility for other tasks too numerous to mention. I wish also to register my deep appreciation to my wife, Phyllis, for her patience and for her frequent assistance in several aspects of writing the manuscript.

I should add, of course, that the responsibility for the use and interpretation of all information provided and for the analysis is mine alone.

J.W. MacNeill,
January 4, 1971.
Ottawa, Canada

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OBJECTIVES AND STRUCTURE

The purpose of this study is twofold: to discuss the present and possible future dimensions of environmental management; and to identify and assess the range of strategies that the various orders of government in Canada may need to employ, separately and jointly, in order to respond effectively to environmental management problems in the future. It is hoped that this will contribute to the continuing discussion of a revised or clarified division of powers for the management of the environment.

In considering a subject as broad and complex as environmental management, one must first set the stage. Part One begins with an outline of the study and a brief but necessary discussion of a few definitions. This is followed by an introductory look at the nature of the problem and consideration of a number of characteristics that all environmental problems have in common.

Part Two identifies some of the main demographic, economic, technological and other forces that generate environmental problems. These are projected into the future and their consequences for environmental management are explored from a global and continental as well as from a national point of view.

Part Three focuses on urban regions. One of the most critical and complex public policy issues facing governments throughout the world is the quality of the urban environment. There are many reasons for this, but the two principal ones are that the majority of mankind has chosen to live and work in urban regions and that most economic life is centred there. Thus most waste is produced by activities within urban regions and its greatest and most immediate impact on man is felt there. The urban environment affects all of man's senses: tasting, smelling, seeing, hearing and feeling. It affects his physical health, his spirit, his perception of good and bad, of beauty and ugliness. He cannot escape its impact.

Part Four examines the environmental problems of non-urban areas. These rural and territorial areas continue to support an important segment of the

population and for many they will always provide the milieu for an ideal life-style. They remain the source of food and raw materials required by the urban-industrial complex. They provide the habitat for a large part of earth's interdependent food-chain upon which all life depends. They are now becoming increasingly important as a refuge and playground for urban man, a place where he can renew his spirit and broaden his esthetic senses. Yet, they remain a significant source of waste from agriculture and resource-based industry and a major repository of waste from urban regions. The preservation of the quality of rural areas has therefore become a goal that must be reconciled with all others.

Part Five considers the atmosphere and waters, the two resources that transcend activities located in urban and rural areas and that receive most of the waste generated by these activities. The environmental problems caused by the resulting pressures on these resources are often inter-urban, supra-provincial, national and even global in scope and their solutions require joint intervention by two or more governments.

Throughout the study the emphasis is on basic underlying trends; the issues that have arisen and may arise and their possible future dimensions; and the *range* of strategies that governments may have to apply at the urban, provincial, national and international levels. The study does not attempt to evaluate the relative effectiveness of different strategies. This would be out of place considering the purpose of the study, and probably impossible considering its time horizon. Nor does the study prescribe policies or programs to deal with specific, current environmental problems. Today's problems will have to be solved within the framework of the existing powers and structures of government.

A FEW DEFINITIONS

Discussions about the management of the environment are often plagued by misunderstandings and vagueness. This is due in no small part to the fact that the words *environment* and *management* mean quite different things to different people.

Environment is a term that has many connotations. Its widespread currency reflects a growing perception of the interdependence of man's actions. This study is concerned with the quality of the physical-natural environment – the air we breathe; the water we drink and use for recreation; the land we cultivate, mine and build on; the cities we flock to in growing numbers; and the wilderness we seek to enjoy today and to preserve for future generations.[1] It is concerned with the physical-natural environment primarily because this is the habitat of man and

[1]The physical environment has been comprehensively defined as "the sum of all, social, biological, and physical or chemical factors which compose the surroundings of man": Environmental Pollution Panel, President's Science Advisory Committee, *Report: Restoring the Quality of Our Environment* (Washington, D.C., 1965), p. 93.

of the millions of plant and animal species with which he shares planet Earth. The growing and cumulative deterioration of this environment threatens man and the complex, interconnected life-system upon which he depends and of which he is a part. The physical-natural environment, of course, is only part of man's total environment. Within that total environment it both conditions and is conditioned by economic, social, political and cultural environments. It both contributes to and is affected by the overall quality of life in our society.

Management is another term that may convey many different meanings. In the past it has perhaps been most commonly used to describe a "function", as in forest management or water management and often in the rather restricted sense of allocating the resource among uses. In the context of the subjects dealt with in this study, it is often confused with "development", as in urban development, rural development and resource development. Recent writing on the problems of the environment, however, views management as a *process* with development as only one function in that process. Management is seen as a *process* that begins with *goal setting* and extends through the functions of *information systems, research, planning, development, regulation* and *financing.* It is in this general sense of a *process* rather than a function that we shall use the term *management.*

These same terms will be used to describe the *functions* employed by government in environmental management. In order to facilitate discussion, the number of functional categories should be limited and six is a manageable number. Since there are literally hundreds of specific functions that might be employed to influence environmental management, however, these six terms must be very broadly defined. With this in mind, *information systems* is a function defined to encompass the collection, storage, analysis, distribution or publication of data, inventories, advice or ideas by means of words, sound, print, electronic pulse or any other means. *Research* encompasses all types of research whether conducted within public agencies or commissioned by public agencies. *Planning* presumes the establishment of goals and objectives. It includes the creation of plans to be implemented by or through the public and private sectors. *Development* includes the implementation and operation of any programs, projects or services undertaken for economic, social, health, cultural, environmental or any other objectives. *Regulation* embraces both the enactment and the administration of laws and regulations, whether of a preventive, curative or punitive nature. *Financing* includes both raising revenue by taxes or fees and making expenditures by grants, loans, cost-sharing, transfer payments or any other method. It includes taxes or fees that might be imposed or expenditures that might be made to provide incentives to components of the private sector to undertake certain activities or to adopt certain policies.

Taken together these functions and any related, derived or subsidiary functions comprehend the entire spectrum of functions that might be employed by the public sector to influence environmental management. They are employed by all orders of government in the Canadian federal system respecting activities

under their jurisdiction. Any given mix of functions and activities may constitute a strategy.

It is difficult to achieve a consensus on what the subject of "environmental management" should and should not include. This will always be true. The quality of the physical-natural environment is the product of human value structures, so both collective and individual values are involved as well as the institutional and political mechanisms for expressing choice and obtaining agreement.

Chapter II

Aspects of Environmental Management

THE GROWING CRISIS

Throughout the world, value structures and institutions are being challenged as seldom before. A major challenge to both stems from the growing, global crisis of the environment. During the middle decades of the twentieth century mankind has become increasingly aware that life on planet Earth is seriously threatened. Man's exploitation of his natural environment to nurture his economic machine is resulting in unsustainable pressures on that environment. His utilization of artificial environments – the cities, office complexes, factories and homes in which he spends most of his time – is resulting in increasing stresses on him. Population growth, urbanization and industrialization are being propelled by an exploding and unregulated technology.[2] The costs of this process in economic, social, ecological, esthetic and psychic terms are becoming increasingly intolerable.

This process will be discussed in detail later in this study but one might recall here a few of its costs and contradictions. Lake Erie is dying and her sister lakes are slowly succumbing to the same sickness. The beaches at Santa Barbara are still and oil drilling is proposed for the Straits of Georgia. The *Arrow* has gone down and the *Manhattan* completes another voyage. Upland game in southern Alberta is poisoned by pesticides and thousands of new chemicals of unknown toxicity enter the environment each year. Our cities are enveloped in smog and the pressure grows for more and faster expressways. The rising crescendo of noise threatens human health and the green light is given to supersonic transport.

And beyond this rampant process of environmental overloading is the most fearsome reality of all – the global scale of many of these phenomena. However vast their territory, Canadians cannot escape the impact of environmental

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[2] See United Nations Economic and Social Council, *Problems of the Human Environment: Report of the Secretary General* (Doc. E/4667, 47th Session, 1969), p. 5 (hereinafter referred to as 47 U.N. ECOSOC, *Problems of the Human Environment*).

deterioration caused by growth pressures in the United States and other regions of the world. The environmental crisis may derive from and be felt most acutely in urban regions but it is provincial, national and global in scale. The oceans, the atmosphere, our fresh water and land resources respect no artificial boundaries; nor does the interconnected food chain they support.

Today, Canadians realize that it is no longer possible to take for granted clean air and pure water, the productivity of our soil and sea resources, or the charm of the countryside. And they sense that it is becoming increasingly difficult to find in burgeoning cities the peace and beauty essential for the sustenance of the human spirit.

This prospect has aroused a deep concern that reflects a history shaped by nature and open space and a conviction that beauty is an essential quality of a civilized environment. Perhaps equally important, it reflects an increased level of education coupled with new and sophisticated mass communications techniques. These have heightened perception of the awesome implications of environmental pollution and they have sharpened our sensitivities about urban ugliness, congestion and blight.

This concern has developed into a consensus that environmental management is a major problem that demands priority attention. Although governments in the future will continue to pursue the goals of growth, they must become more concerned about the alarming negative effects ot this growth upon man and his environment.

Fortunately, the very forces that breed the problems – principally knowledge, technology and wealth – can provide Canadians and others with the capability to solve them. Research can certainly devise technological answers to technological problems – pollution-free means of transporting goods and people, noiseless industrial machines, more effective methods to dispose of wastes. It can also increase the vast array of environmental management strategies now available. The need for this is evident and the past decade has seen growing public demand for clear and strong government intervention, despite the jurisdictional haze that envelops environmental management in Canada.[3]

PROPRIETARY RIGHTS AND LEGISLATIVE JURISDICTION[4]

At present, all orders of government have substantial roles to play in managing the environment – federal and provincial authorities by virtue of a wide variety of powers, and municipal authorities with the powers and responsibilities assigned them by provincial legislatures. This much is widely acknowledged. There is considerable disagreement, however, about where the boundaries lie

[3] See Dale Gibson, *Constitutional Jurisdiction Over Environmental Management in Canada* (Unpublished, 1970).
[4] *Ibid.*

between the jurisdictional spheres of each government. This jurisdictional uncertainty presents real obstacles to the satisfactory integration of environmental management programs. It also makes it difficult to describe the existing jurisdictional framework. All that can be offered with confidence are a few very general comments about matters that seem to be beyond dispute.

One of the most important keys to understanding the present jurisdictional framework respecting environmental management in Canada is an awareness that the *proprietary* or ownership rights of each government with respect to the environment differ substantially from their *legislative* or law-making rights.

Most natural resources lying within provincial boundaries that are not privately owned belong to the Crown in the right of the province. This would include land, water, minerals, timber, wildlife and, to some extent at least, the air-space. The proprietary rights of the federal Crown with respect to resources located within a province are very limited in comparison to the rights of the provincial Crown, but they are by no means insignificant. The federal government owns certain national parks, harbours, canals, and other property within provincial boundaries; and it also has the power to acquire resources by purchase, or by expropriation for purposes within its legislative jurisdiction. In addition, the federal government owns all Crown rights to resources lying outside provincial boundaries – in the northern territories and beneath Canada's territorial waters.

If jurisdiction over environmental management were based solely on ownership of natural resources, it would be relatively simple to describe, but it is not. Both senior orders of government have legislative powers that are in addition to their ownership rights, and that empower them to make a variety of laws relating to environmental management, even to the point in some cases of allowing them to affect resources owned by the other government. This division of law-making powers between the federal Parliament and provincial legislatures is much more complicated than the division of ownership rights.

Any attempt to describe fully the respective federal and provincial legislative powers in this field would be too lengthy and too conjectural to be appropriate in this context. A few generalizations may be helpful, however. "Environmental management" is not recognized as a distinct category of constitutional jurisdiction; indeed, it is so broad a field that it touches many areas of constitutional authority, both federal and provincial. For this reason, both orders of government have very important constitutional powers relating to environmental management. Some aspects of the subject fall within the exclusive authority of the provincial legislatures (e.g. most problems of urban transportation) and other aspects are entirely within federal jurisdiction (e.g. pollution that crosses the international boundary). In many cases, however, the legislative powers of the federal and provincial governments overlap, with the result that either may make laws on the subject, but the federal laws will prevail in the case

of conflict, which is rare. The federal government has also become involved in many activities outside its express legislative jurisdiction by employing what has been called its "spending power" – the right to grant or lend money (often with conditions attached) to assist those engaged in activities within the provincial ambit. Several other methods of achieving federal-provincial co-operation have also been developed. The Canada Water Act is a most recent example.[5] It enables the establishment, by agreement, of joint federal-provincial bodies to undertake integrated research, planning, development or management of waters over which both orders of government have legislative jurisdiction.

If Canadians are to restore and enhance the quality of their environment, concerted action at the international, national, provincial and urban levels will be required. Some of the many available strategies can be applied more effectively by one order of government than another. Some can be applied unilaterally by one government and some must be applied in co-operation with other governments. Moreover, the order of government in the best position to apply any given strategy in a given way may change with changes in the underlying structure of society. The ability of all governments to respond effectively, therefore, depends not only on the jurisdictional framework at any point in time, but also on the facility with which this framework can be modified and shifted. This would appear to require, among other things, a flexible framework that in some way recognizes and is sensitive to the changing dimensions and dynamics of the problem.

THE ECOLOGICAL PERSPECTIVE

Man and all living things are subjects of a global ecological system. This global system has many component *ecosystems,* all interdependent, all tied together by an infinite web of linkages. The urban regions discussed in Part Three of this paper may be viewed as ecosystems, made up of thousands of sub-systems. So may the rural and territorial areas and their grasslands, forests, shields and mountains. Similarly, the atmosphere and the inland rivers, coastal estuaries and oceans are all interrelated ecosystems.

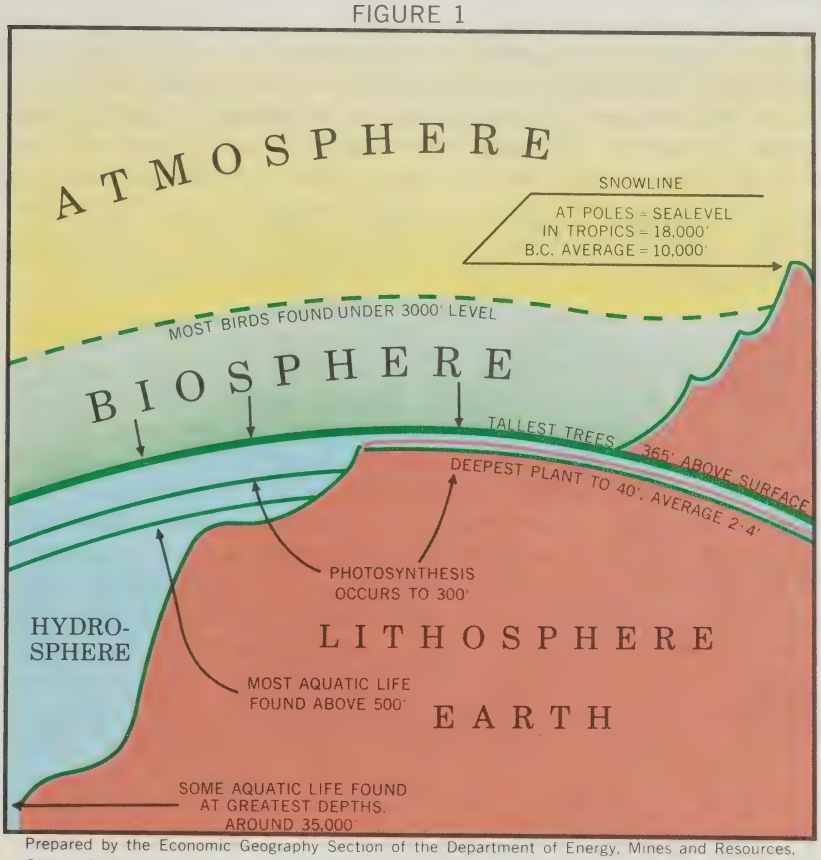
The ecological system contains the biosphere, the living part of the land, water and atmosphere of the planet which is depicted in Figure 1. A thin envelope circling the globe, the biosphere sustains a hierarchy of millions of plant and animal species, including man, all interconnected and dependent upon one another for life support. It is this living system that is threatened by environmental degradation. Throughout this study, in discussing the pressure of human activities on air, land, water and other resources, the primary concern is always

[5] Statutes of Canada, 1970, c.52. See also the remarks of the Hon. J.J. Greene, Minister of Energy, Mines and Resources, in moving second reading of Bill C-144, Canada, *House of Commons Debates,* November 20, 1969, pp. 1042-53.

with the side effects of this pressure on the biosystem, and especially on man.

The global ecological systems and biosystems have many characteristics. There are four, however, that appear to be central both to the relationship between human activity and environmental quality and, indirectly, to appropriate roles of different governments in environmental management. These are the fact of a finite planet, photosynthesis, biological magnification and the rising level of by-products in the atmosphere.

FIGURE 1



Prepared by the Economic Geography Section of the Department of Energy, Mines and Resources, Ottawa, August, 1970.

The planet Earth and its atmosphere is a finite, closed system. This assertion has needed no supporting argument since the first breathtaking photographs of the Earth from the Moon. Man could see himself and his home as an isolated island in space. But prior to this, a number of less dramatic events had gradually led increasing numbers to grasp the implications of this fact. The spread of radioactive fall-out, the long circuit of D.D.T. from someone's garden to the tissue of Antarctic penguins, the knowledge that many members of the food-chain are endangered, have all underlined the overriding necessity for man to heed the fact that he lives in a closed system.

All living organisms in this system, including man, receive inputs from it in the form of air, food and water and they give off outputs. Man's economic machine, too, receives inputs from the earth, the atmosphere and the waters and gives off outputs into these finite reservoirs.[6] Sooner or later all outputs take the form of wastes because very little material is actually consumed by man or his economic machine; at most the material is transformed and passed on. There are really only three things that man can do with his vast tonnage of waste: bury it, burn it, or wash it away. By far the greatest quantity is washed away into our lakes and rivers and ground water and eventually drains to the sea, our ultimate garbage "sink".

The by-products of man's activity can alter this closed system fundamentally. Moreover, the assimilative capacity and resilience of the global biosystem are unknown. A change in any one variable may trigger a change in the whole. Its capacity has already been exceeded at certain points and man is pressing its limits at more and more points. When his activities reach a level where they interrupt the biosystem (especially the lower forms of life involved in the primary conversion of energy into oxygen and food) they can have profound implications for all living organisms and ultimately endanger human survival.

The second characteristic, photosynthesis, is the basis of all life on earth. It is the process by which green plants on land and small aquatic plants in our lakes and oceans take in carbon dioxide and produce oxygen during the day. They reverse this process during the night, taking in oxygen and giving off carbon dioxide. All available oxygen, which makes up 21 per cent of the atmosphere, is produced by photosynthesis. Moreover, the delicate oxygen-carbon dioxide balance is maintained by this process. Man is now seriously disturbing this balance. On the one hand, we are reducing the ability of aquatic and terrestrial plants to produce oxygen. Over 70 per cent of our total oxygen supply is believed to be produced by minute aquatic plants. They also form the base of most of the ocean's food chains. It has recently been found that very small concentrations of pesticides such as D.D.T. significantly diminish their rate of photosynthesis.[7] The landscape is the source of the balance of our oxygen and it is being slowly denuded. It is estimated that North America alone is "losing" a net of one million acres per year to cities, highways and timber cutting. On the other hand, the combustion of fuels is consuming vastly increased quantities of oxygen and producing equally large amounts of carbon dioxide, which the reduced plant world is unable to completely recycle.

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[6] See Kenneth E. Boulding, "The Economics of the Coming Spaceship Earth", in *Environmental Quality in a Growing Economy*, Henry Jarrett, ed. (Baltimore, Johns Hopkins Press for Resources for the Future, Inc., 1966).

[7] C.F. Wurster, "DDT Reduces Photosynthesis by Marine Phytoplankton", *Science* (March 29, 1968), pp.1474-75.

The third characteristic is the rising level of various by-products from man's activity in the atmosphere. Worldwide concern has been aroused mainly by the increasing content of carbon dioxide in the atmosphere, which forms a film or filter around the globe. The cause of this has been noted above, but the percentage increases are quite startling. Last year the United Nations Secretary General reported that the combustion of fossil fuels had caused the carbon dioxide content of the atmosphere to increase by one-tenth over the past century. By the year 2000, with increased rates of fuel consumption, this could rise to an increase of one-quarter over its original level.[8] Two alternate consequences of this increase in carbon dioxide are currently being debated by scientists. If the filter acts as a greenhouse, permitting sunlight to enter but preventing heat radiation from escaping, then average world temperatures would increase. If the filter acts as a reflector, bouncing sunlight away from the earth, then average temperatures would drop. Either way the result would be catastrophic.

In fact, between 1940 and 1960 there was a decrease of about 2° Fahrenheit in annual mean temperatures and this trend has continued throughout the past decade. This may stem from the effects of increased turbidity in the atmosphere, caused by higher levels of dust, carbon and solid air pollutants generally. It has recently been demonstrated that there was a 30 per cent increase in turbidity over the Pacific between 1957 and 1967.[9] Washington, D.C. experienced a 57 per cent increase between 1905 and 1964 and Davos, Switzerland, 88 per cent from 1920 to 1958.[10] This has a screening effect, like a thin cloud, reducing the amount of sunlight reaching the earth.

The fourth significant characteristic of the global system is biological magnification. It stems from the ability of aquatic organisms, plants and animals to concentrate toxic, radioactive and other elements. Shellfish and other marine organisms, for example, have the ability to concentrate radio nuclides and, as invertebrate animals, they are capable of withstanding high concentrations of radioactivity without apparent harm. "Concentration factors" have been evaluated for many organisms and elements and they range from less than 1.0 to over 100,000. As smaller plants and fish and animals are eaten and passed up the food chain the higher concentrations may result in serious disabilities or death in

[8] 47 U.N. ECOSOC, *Problems of the Human Environment,* p.5.

[9] J.R. Peterson and R.A. Bryson, "Atmospheric Aerosols: Increased Concentrations During the Last Decade", *Science* (October 4, 1968), pp. 120-21.

[10] R.A. McCormick and J.H. Ludwig, "Climate Modification by Atmospheric Aerosols", *Science* (June 9, 1967), pp.1358-59.

creatures at the upper end of the food chain. Or before this stage is reached, the plant or animal may be eaten by man, with equally disastrous results.[11]

Man to date has unfortunately not been noted for his respect of his complex, interconnected, finite habitat. In the future, he needs to be much more aware of the possible impact of his activities on the global ecological and biological system. This awareness needs to be reflected in his basic laws and his governmental and intergovernmental arrangements. On his closed planet, the net waste output of an urban region, province, even a nation, conditions the resource inputs of other similar spatial units. Burning wastes rather than washing them into our streams does not solve the problem; it merely shifts the initial impact from one component of the environment to another and it often shifts it from one jurisdiction to another. At the same time, we can't very well fire our residual waste into outer space. We have to dispose of it somewhere on the earth and in its atmosphere.

SPILLOVERS

Environmental management problems stem from the inter-action between human activity and the natural environment. All human activity – social, economic and cultural – generates side effects that benefit one part of the community at the expense of another. A popular example at the moment is that of a community or industry dumping its waste into a river. It is taking advantage of a natural public asset to secure a cheap method of disposal but its action may increase the cost of treating water supplies by other communities downstream. It may also prevent the downstream use of the water by people for bathing or by farmers for irrigation, or it may destroy fish spawning grounds and other wildlife habitat.

Side effects can be less obvious and more pervasive, however. They can also be positive as well as negative. The concentration of population within an urban region, for example, or the close proximity of many urban regions can provide conditions that naturally attract commerce and industry to a particular community. Because of the ready source of labour and other factors of production, as well as the size of the adjoining market, industries locating there almost automatically enjoy lower unit costs and they are able to pay higher wages and salaries. The higher incomes attract more people. The cycle continues and the circle of inter-relationships emanating from the community widens until the

[11] Examples of organomercurial poisoning in Japan at Minimata Bay, and more recently, in the Agani River, dramatically illustrated that the long-term ingestion of mercy-contaminated fish can lead to death or permanent neurological and mental disabilities. Sweden and, this year, Canada have detected high levels of mercury in fish. In this context, see also N. Fimreite, "Mercury Uses in Canada and Their Possible Hazards as Sources of Mercury Contamination", Manuscript Report No. 17 of the Pesticide Section, Canadian Wildlife Service (March, 1970).

entire national economy may feel the impact. The leaders of our educational and cultural establishments tend to concentrate in our large urban regions for similar reasons. Their values, tastes and prejudices become reflected in school curricula, the media and the arts and over time influence the standards and life styles of the nation.

The side effects of activities in one jurisdiction that spill over into other jurisdictions have been descriptively christened by economists as "spillovers". The same term is often applied to side effects of activities involving one resource that spill over into another resource, for example air pollutants deposited on land or water. Side effects are not a new phenomena, but the growing scale of human activity harnessed to modern technology and the increasing interdependence of people, resources and communities, have caused environmental spillovers to command increased attention.

The policies of one jurisdiction can and usually do have a considerable impact on another. It is a common observation that as urban settlement spreads across lines of local jurisdiction, the city and its suburbs come to comprise a single integrated area for living and working. Within a single urban region, local communities typically share many kinds of resources for urban living: air and water supplies, parks and recreation areas, commercial and cultural centres. They also share many facilities that cut across local boundaries such as utilities and highways. Other facilities, such as airports, may serve several urban regions. Facilities such as harbours may serve several provinces. If one jurisdiction fails to control air and water pollution, its neighbors suffer. If one jurisdiction fails to expand transportation facilities – highways, expressways, harbours, airports – or if it expands them without regard to the environmental costs imposed on other jurisdictions, the total overall costs may well exceed the total benefits.

The field of public health is rich with examples of environmental spillovers. Vehicular exhaust generated by automobile traffic originating in suburban municipalities can cause eye irritation and headache, confusion and dizziness in urban dwellers. The noise of large jets taking off from international airports near urban areas results in annoyance and irritability and even in permanent hearing impairment in residents of the surrounding community. Mercury used in certain industrial processes may concentrate in fish and cause general debility, brain damage and death to individuals who eat the fish, although they may be far from the source of the pollution. High sulphur fuels in industry and public utilities can cause increased morbidity or mortality from respiratory conditions among the urban population. Moving air masses can transmit this from one community to another, carrying both the pollution and its consequences to human health across urban, provincial and international borders.

It is evident from these examples that side effects carry costs and that, because of the spillover phenomenon, these costs may be external to the activity, industry or jurisdiction responsible. Economists refer to these costs as "external

costs". They are often hidden, pervasive and intangible, defying precise quantification. In the environmental field they are often much more significant than the direct costs of an activity. Indeed, some experts view environmental management largely as a problem of "internalizing" these external costs.

It is evident from these examples that an understanding of the spillover phenomenon is crucial to sound environmental management. Within a federal system, it is also important when considering the roles and powers of different orders of government. Any given political jurisdiction may face three possible types of environmental problems. There are those whose source and effects are all contained wholly within the spatial boundaries of its jurisdiction. There are others whose source is within, but whose effects spill over the boundaries of its jurisdiction, and there are still others whose source is outside but whose effects spill into the boundaries of its jurisdiction. The following chapters demonstrate that only in the first case does the government of the jurisdiction in question have both the incentive and the power to deal fully and effectively with the problem. In the latter two cases, joint action by another one or more jurisdictions, domestic or foreign, is required. This joint action may be undertaken by co-operative agreement between the jurisdictions involved or, within a federation, it may be, where appropriate, undertaken by an order of government whose jurisdiction embraces the entire region affected. In any event, inter-jurisdictional action is required if the problem is to be resolved.

The spillover phenomenon, then, is a useful guide in considering the role of and relationships between different orders of government in a federal system. Its application should, of course, be tempered by other principles such as political access and administrative efficiency. The increasing prevalence and pervasiveness of spillovers, however, will always provide a powerful argument for inter-jurisdictional co-operation regardless of the powers of different governments at any point in time.

PUBLIC GOODS

An important characteristic shared by many "environmental goods" is their non-marketability. They simply do not lend themselves to production or packaging or to allocation by price. Clean air, clean water and a quiet neighborhood, for example, are open to the enjoyment of anyone; no one can be excluded from their benefits. The corollary of this is that it is rarely in a single individual's private interest to supply these goods; they normally must be supplied by the people as a whole through the public sector. With a few exceptions, this is true of the whole range of "environmental quality goods". They are "public goods".

When one couples the characteristic of "public goods" with the spillover phenomenon and the characteristics of the ecological system discussed above, it seems evident that effective environmental management will require an increasing

degree of public intervention in the future, at the urban, provincial, national and international levels. This is not to diminish the role of the private sector. There are various ways of dealing with the spillovers of social and economic activity, within and between jurisdictions. While all seem to require some form of public intervention, it currently appears that some of the most effective can be undertaken only by or through the private sector.

The following chapters will mention, but not evaluate, a number of possible environmental management strategies. By and large, however, they may be grouped into two broad approaches. Under the first, public intervention would serve to induce or compel the economic unit responsible for an activity to anticipate all of its side effects and to take their costs into account when production and marketing decisions are made. In other words, where a proposed economic activity might result in economic or social losses external to an industry or a community, these losses would be considered part of the cost of the activity. This general approach has been summed up in the phrase, "the polluter should pay". It would rely heavily on measures designed to "internalize" the environmental costs of an activity to the industry or community in question. These measures might take the form of taxes, grants, effluent charges or other incentives.

Under the second approach, public intervention would take the form of more direct regulatory measures. Various types of agencies would be responsible for anticipating the side effects of a proposed activity and monitoring and controlling the level of the side effects to ensure that they do not exceed the assimilative capacity of man and his fellow subjects of the biosystem. These approaches might, of course, overlap. Incentive strategies could include regulatory measures and vice versa. Both approaches, too, have important spatial and jurisdictional implications.

AMENITY RIGHTS

The various components of a quality environment – open spaces, attractive neighborhoods, clean air and water, quiet – are beginning to be regarded not only as public goods with the characteristics discussed above, but also as "amenity rights" to be recognized in law and guarded and protected as jealously as many other fundamental rights:

> The arguments for extending legislation to cover men's rights to basic natural amenities are *no different in kind* from those used in defence of men's rights to private property, in particular those turning on equity and economic efficiency. With respect to equity it is a cardinal liberal tenet that every man should be allowed to pursue his own interest *provided* that in doing so he inflicts no harm on others. The

post-war eruption of environmental spillovers forms a classic instance of the most blatant infringement of this crucial proviso . . . .[12]

THE SPATIAL ASPECTS OF ENVIRONMENTAL MANAGEMENT

In relating environmental management to the constitution, the spatial dimensions are important for at least three reasons. First, space is an important characteristic of all environmental problems. It is commonplace to observe that neither air nor water pollution respects man-made boundaries. Second, space is an essential attribute of all forms and orders of government. The very terms *rural, urban, provincial, national* and *international* carry a fundamental spatial connotation.[13]

Third, efficient and effective environmental management often requires some degree of coincidence between problem area and power. Historically, this has been difficult to achieve.[14] It is easy to understand why this should be so in the case of supra-national problems, although Canada and the United States have been relatively fortunate in this regard largely because of the efforts of the International Joint Commission.[15] It is more difficult to comprehend in the case of supra-provincial and inter-urban problems.

Within federal nations, the difficulty appears to derive from the interdependence of most environmental problems on the one hand, and the need to divide jurisdiction between different orders of government on the other.[16] Divided jurisdiction, however, need not frustrate effective environmental management. Certain strategies can be applied and certain tasks performed more effectively at one level than another. Indeed, if environmental management were the only problem of government, efficiency and other criteria such as scale and access would dictate that it be decentralized within and between different orders and levels of government.

Fortunately, this is compatible with the fundamental concept of federalism. Matters that are essentially local or provincial in nature and scope, and that are and should be responsive to the diverse preferences of people in different

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[12] E.J. Mishan, "The Spillover Enemy: The Coming Struggle for Amenity Rights", *Encounter,* XXXIII (December, 1969), p. 8.

[13] For a more complete discussion of the spatial perspective see C.I. Jackson, *The Spatial Dimensions of Environmental Management in Canada* (Unpublished, 1970).

[14] See *Area and Power, A Theory of Local Government,* Arthur Maas, ed. (Glencoe, Ill., Free Press, 1959).

[15] See Document P/217 of the International Conference on Water for Peace, Washington, 1967, a paper prepared for the International Joint Commission by Matthew B. Walsh and A.D.P. Heeney.

[16] See J. Stefan Dupré, "Intergovernmental Relations and the Metropolitan Area", in *Politics and Government of Urban Canada: Selected Readings,* L. Feldman and M. Goldrick, eds. (Toronto, Methuen, 1969), pp. 183-84.

communities, can best be dealt with by local and provincial governments. Matters that are essentially national or international in scope or that are most amenable to strategies applied at that level, can best be dealt with by the federal government.

The analysis of environmental problems in this paper does not violate this fundamental concept. The urban region, for example, emerges as the appropriate spatial unit for the management of some aspects of many environmental problems. In general, it would appear that governments of urban regions should have the powers and resources to apply those strategies required for the solution of problems having both their source and effects *within* the urban region, and to establish and participate in instruments for effective consultation, coordination, joint planning and development with other orders of government and with the private sector. This statement, however, needs to be supplemented by three observations. First, although the statement applies to all urban regions, only the larger urban regions may have the population and resource base to assume responsibility for the full range of strategies most effectively applied at the urban level. Second, even with the most effective environmental management within larger urban regions, there will be spillovers into other jurisdictions, provincial, national and foreign. Third, the primary sources of many major environmental problems within urban regions lie outside the region and can be resolved most effectively and, in some cases, only by action at the provincial or national level.

With regard to the provincial level, the following analysis shows that the province is the most appropriate spatial unit for the management of other aspects of many environmental problems. Provincial governments need the powers and resources to apply the range of strategies required for the solution of problems having both their source and effects *within* the province, and to establish and participate in instruments for effective consultation, coordination, joint planning and development with other governments within Canada and with the private sector. There are also three general observations to be made regarding this statement. First, in addition to responsibility for environmental management in their agricultural, forested and northern areas, provincial governments need to be in a position to undertake management directly, on behalf of or through urban areas, of the institutional, policy and programme combinations most appropriate to the circumstances. Second, even with the most effective environmental management within each province, there will be spillovers into other jurisdictions. Third, the primary sources of some environmental problems within a province lie outside the province or have national and international dimensions. They can be resolved most effectively, and in some cases only, at the national level.

Finally, because of the spillover phenomenon mentioned above and because many problems have extra-provincial, national and international dimensions, the following analysis demonstrates that the federal government requires the powers and resources to apply a broad range of environmental strategies at the supra-provincial, national and international levels, and to establish and participate

in institutions for effective consultation, coordination, joint planning and development with the private sector and *with* and *between* governments within Canada and governments of foreign states. Two observations may be made regarding this statement. The federal government's exercise of its jurisdiction respecting extra-provincial and sub-national problems could vary depending upon the nature and scope of the problems. Also, since nothing should preclude one or more provinces or urban regions from getting together to solve mutual environmental problems, the federal government's exercise of its powers could depend on the extent to which the other orders of government can or cannot cope, or in fact have or have not coped, with them directly or through inter-governmental arrangements.

PART TWO

THE SOURCES OF ENVIRONMENTAL DETERIORATION

Chapter III

Scope and Method

The genesis of environmental deterioration is to be found in increased population, urbanization, industrialization and technological innovation and their derived products. Normally these are hailed as indicators of growth and standards of the success of public policy. More people with more money enjoying more mobility and more leisure and producing and consuming more per person each year represents both our individual and collective aspirations.

Yet these same goals require ever-increasing quantities of land, water and raw materials. They result in heavier pressures on the environment at all points, causing more air pollution; more crowding in our cities, on our highways and at our beaches; more automobile junkyards; more land stripped for mining; and more species threatened with extinction. The costs and benefits of growth are two sides of the same coin.[1]

The colossal growth in population is of particular significance for the quality of man's environment. In 1850 there were only 1.2 billion people on earth. Today, there are about 3.6 billion, three times as many. Within the life expectancy of Canadians born in the 1970's, this number could reach 11.0 billion or more.[2] The population of Canada and the United States of 215 million in 1965 may increase to 350 million by 2000 and around 500 million by 2020.[3] Canada's population could reach between 30 and 40 million by the turn of the century and, some suggest, perhaps 100 million by 2050.

Equally significant is the spread of urbanization. In the 40 years from 1960 to the year 2000, the world's urban population is expected to grow from less than one billion to more than three billion.[4] Today, 160 million Canadians and

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[1] See E. J. Mishan, *The Costs of Economic Growth* (London, Staples, 1967).

[2] United Nations Economic and Social Council (Population Commission), *World Population Situation: Note by the Secretary-General* (Doc. E/CN. 9/231, 15th Session, 1969), pp. 9-10 (hereinafter referred to as 15 U.N. ECOSOC (Pop. Comm.), *World Population Situation*).

[3] Data are compiled from Herman Kahn and Anthony Wiener, *The Year 2000* (New York, MacMillan, 1967), p. 157.

[4] 15 U.N. ECOSOC (Pop. Comm.), *World Population Situation,* p. 44.

Americans reside in urban areas. By the turn of the century, this number could reach 300 million, about 90 per cent of the combined populations of our two countries.[5] Over 32 million of these could be Canadians, 94 per cent of the projected population.

The per capita production of this massive global population is projected to triple between now and 2000. In Canada and the United States, the work week may decline from slightly over 38 hours to perhaps 30 hours a week or less, depending on whether we choose to trade increasing productivity for more leisure or more income.

The magnitude and speed of these trends of population growth, population concentration, and increased leisure time are unprecedented. Coupled with other concurrent economic, technological and other trends, they threaten an enormous increase in worldwide and national pressures on the environment.

In Part Two, the strength and persistance of these forces are examined along with their implications for environmental management. They are examined initially from a global point of view. As mentioned earlier, Canada cannot escape the impact of environmental deterioration caused by growth pressures in the United States and the rest of the world.

These forces are also examined from the point of view of the future. Since we are concerned with the role of government in environmental management, we must attempt to anticipate the possible shape and scale of environmental problems over the next 30 years at least. Two-thirds of all Canadians now alive will witness the year 2000 and however distant that date may now seem, governmental planning, including constitutional revision, should take account of demographic, economic, technological and other trends that are already apparent and will accelerate.

Although the importance of a future perspective hardly needs emphasis, the problems of long-range forecasting will no doubt be raised. Some will observe that forecasting 30 years into the future is hazardous, if not impossible, since a multitude of variables, especially technology, will influence trends in quite unpredictable ways.

Although the risks are evident, they can be avoided for purposes of this study. The concern is only with broad orders-of-magnitude, not with precise values. The methods used for most of the projections provide a range of possible values for each target year. Most important, the projections are indicative; they are not predictive. It is vital that this last point be understood and its implications appreciated. The projections do not purport to *predict* what the 10, 20 and 30 year future *will* bring in terms of population, urbanization, economic growth. Rather, they *indicate,* within an increasingly broad range of values, what the future *could* bring *if* existing constraints imposed by public policies and other factors are not

[5] See Figures 5 and 6.

modified. In the same way, they indicate the possible shape of future environmental problems, which can be deduced from the basic demographic, economic and other projections.

In view of this, it is clear that clairvoyance is not a quality sought in these projections. Indeed, given the environmental consequences of many of these projections, as outlined in the following chapters, it may be said that their value will be determined more by the extent to which they are not realized than by the extent to which they are. Long-range projections of this type are becoming more necessary as society becomes more explicitly committed to the conscious choice of social ends after a careful assessment of the possible consequences of alternative directions of social change. Long-range projections can also facilitate consideration of constitutional change. They help to identify the basic constraints that need to be modified if the direction of the trends is to be shifted. They also help to indicate the order of government in the best position to apply the necessary strategies and policies.

The relevant trends are considered in the next three chapters on population and economic growth, urbanization and industrialization, and research and technology. Although it is necessary for purposes of discussion to consider these trends separately, it should be borne in mind that they act concurrently and are mutually interdependent.

Chapter IV

Population and Economic Growth

The arithmetic of world population growth coupled with world economic growth provides a global framework for the environmental problem. A recent report on problems of the human environment observes that for most of the time that man has existed his numbers have been small and his powers limited.[6] Damage to his environment has been local and usually well within the regenerative capacity of his surroundings.

It took several million years for the world's population to reach a total of 0.8 billion. As shown in Figure 2, the world's population increased by less than one-half billion in the 100 years between 1750 and 1850, and by only 1.2 billion in the following hundred years to 1950. It has jumped by more than a billion in the last 20 years, however, and it could double again in the next 30, reaching six to seven billion by the year 2000. A further 4.0 to 6.0 billion could be added in the following 50 years! [7]

The population of North America has also experienced phenomenal growth during the past century and this rapid rise in absolute numbers is expected to

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[6] United Nations Economic and Social Council, *Problems of the Human Environment: Report of the Secretary-General* (Doc. E/4667, 47th Session, 1969), p. 4.

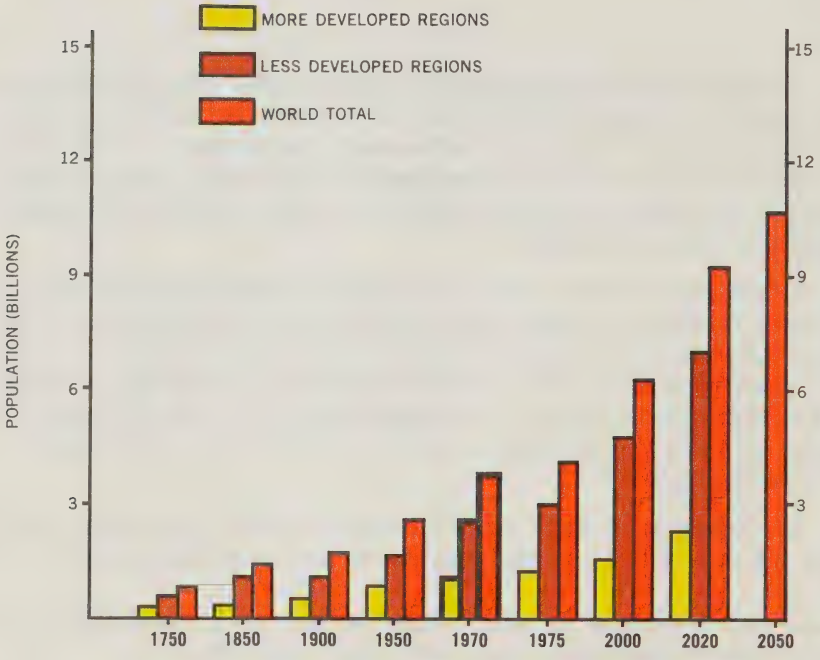
[7] 15 U.N. ECOSOC (Pop. Comm.), *World Population Situation*:

> These estimates are according to the studies of Durand; for the period 1920 to 2000 they also conform with recent estimates and projections of the United Nations. Increasingly speculative estimates extending into the subsequent century suggest that *fertility decreases assumed in the U.N. projections* in the immediate future decades could become consistent with a complete cessation of world population growth by the end of yet another century. Perhaps the world total may then be of the order of 15,000 million. (p. 9, emphasis added).

The annual increments reflected in these estimates are even more startling. Referring to the "demographic revolution", the report notes that in periods up to 1850 annual increments in total population amounted to four to six million inhabitants, of which only one to two million occurred in the "more developed" regions. In the first half of this century, these increased to 18 million per year, six million in the "more developed" world. We are now faced with annual increments of 73 million, 12 million in the "more developed" regions and 61 million in the "less developed". (p. 12).

FIGURE 2

WORLD POPULATION ESTIMATES AND CONJECTURES: 1750-2050



1750-1950 and 2050 data are from 15 U.N. ECOSOC (Pop. Comm.), World Population Situation, pp. 9-10. Data for 1975-2020 are taken from Kahn and Wiener, The Year 2000, p. 139. All estimates are based on "medium" assumptions. "More developed regions" includes North America, Europe (including the entire Soviet Union), Japan, temperate South America, Australia and New Zealand. "Less developed regions" includes the rest of the world.

continue. The relevant figures for Canada and the United States, with projections to the year 2000 and beyond, are set out in Table 1. This table reveals that in the one hundred years from 1850 to 1950 Canada's population increased more than five-fold to 13.7 million. In absolute terms, however, we added only slightly more than 11 million. It has taken just twenty years to add a further 7.5 million Canadians. Low projections to the year 2000 indicate that we could increase by a further 13.0 million (60 per cent) to 34.0 million. Given the "right" mixture of fertility and immigration, however, we could add 20 million (92 per cent) and turn the century with a population of over 41 million. The U.S. figures reveal similar rates of increase.

Table 1[a]

Population Estimates and Projections
Canada and United States
1850 – 2020
(millions)

	Canada		United States	
1969	21.0			–
1850	2.4	–	23.3	–
1900	5.4	–	76.1	–
1950	13.7	–	151.7	–
1975	23.3	(23.2 – 24.4)	222.	(219 – 230)
1980	25.4	(24.8 – 27.1)	235.	(228 – 250)
1985	27.5	(26.6 – 30.3)	256.	(246 – 274)
2000	34.0	(30.3 – 41.6)	318.	(290 – 362)
2020	46.0	(46.0 – 68.0)	420.	(370 – 500)

[a]Canadian estimates for 1850 and 1900 are taken from *Historical Statistics of Canada,* M.C. Urquhart and K.A.H. Buckley, eds. (Toronto, MacMillan, 1965), p. 14. Canadian estimates for 1950 are taken from Dominion Bureau of Statistics, *Estimated Population of Canada by Province* (Cat. 91-201, 1968), p. 2. United States estimates for 1850-1950 are taken from U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1957* (Washington, U.S. Gov't. Printing Office, 1960), p. 7. U.S. projections for 1980 are taken from U.S. Department of Housing and Urban Development, Technical Paper No. 4, "Trends and Projections of Future Population Growth in the United States, with Special Data on Large Urban Regions and Major Metropolitan Areas, for the Period 1970-2000", p. 4 (hereinafter referred to as U.S. Department of Housing and Urban Development, "Trends and Projections"). This paper was presented by J.P. Pickard, Office of the Deputy Under Secretary of State, to the *Ad Hoc* Subcommittee on Urban Growth, Committee on Banking and Currency, U.S. House of Representatives, July 22, 1969.

Canadian and U.S. projections for 2020 and U.S. projections for 1975 and 1985 are taken from Kahn and Weiner, *The Year 2000,* p. 157. Canadian projections for 1975-2000 are taken from Systems Research Group, *Canada: Population Projections to the Year 2000* (Toronto, 1970). S.R.G.'s high projections assumed high fertility, medium mortality and medium migration; their preferred projection reflects medium assumptions throughout.

Accompanying this "demographic revolution" is the national and international pursuit of economic growth. As measured by such indices as gross national product, disposable income and leisure time, this pursuit has been remarkably successful in the more developed nations of the world and studies suggest that both the goal and the success in achieving it will continue. Studies also suggest that future growth will be shared by the less developed nations. This is illustrated by Table 2 and Figures 2 and 4. These and the other economic indices offered provide a base from which inferences may be reasonably drawn respecting the dimensions of future pressures on the environment. Unfortunately, better, more direct indices, are not available on a global basis although several specific national estimates will be cited later.[8]

World projections of population, gross national product and gross national product per capita are presented in Table 2 compiled from figures published by the Hudson Institute. The table provides comparative projections for the "less developed regions" and the "more developed regions" with Canada and the United States shown separately. It suggests that the gross world product may increase by 5.1 times, rising from $2.1 trillion in 1965 to $10.9 trillion in 2000.[9] This increase is the result of the fairly high annual growth rates assumed, averaging 4.8 per cent. Even if the assumed growth rate were reduced to three per cent, however, gross world product in 2000 would still be $6.0 trillion, an increase of three times in three decades.[10]

Per capita world product in 1965 was around $630. This was approximately one-fourth the Canadian figure and one-sixth the U.S. "By the year 2000, per capita world product could be $1,700, within a range of $880 and $2,200 depending on the growth rates used to project the GNP's of individual countries".[11] The medium figure of $1,700 would be nearly one-fifth the projected Canadian per capita product and would remain one-sixth of that projected for the USA.[12]

A summary of key economic projections for Canada is displayed in Table 3. These projections suggest that the Gross National Product will rise from four

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[8] In assessing these figures, we should recall that gross national product is far from a perfect measure of economic growth and is an increasingly poor measure of national welfare. It is a blind, neutral summation of the current money value of all expenditures. Great pains are taken to avoid double counting but equal value is given to $100 whether it is spent on groceries, a gun to hold up a bank, or a highway billboard that increases traffic hazards. In brief, the GNP measures both the nation's health and its sickness, but it doesn't differentiate between the two.

[9] Kahn and Wiener, *The Year 2000,* p. 138.

[10] *Ibid.*

[11] *Ibid.*

[12] It is of interest to note that in 1965, the per capita product of the more developed exceeded that of the less developed by about twelve times. If these projections are borne out, by the year 2000 the gap will increase by 50 per cent to a factor of eighteen.

and one-half to six times between 1967 and 2000, depending on the assumptions employed. If it grows at the fastest rate it will double every 13 years; even if it grows at the slowest rate it will double every 16 years. The figures also indicate that per capita GNP could double by 1985-90 and triple by 2000. Moreover, personal expenditures per capita could rise from $2,000 in 1967 to between $5,400 and $7,600 in 2000 – a two and one-half to fourfold increase in 30 years!

Table 2[a]

World Population, Gross National Product and GNP/Capita
1965 and 2000

More Developed Regions	1965	2000
Canada		
Population (Millions)	20	34
GNP (Billions 1965 $US)	48.3	266
GNP/Cap (Thous. 1965 $US)	2,464	7,820
United States		
Population (Millions)	195	318
GNP (Billions 1965 $US)	692.3	3,231
GNP/Cap (Thous. 1965 $US)	3,557	10,160
Other More Developed Regions		
Population (Millions)	865.9	1,260
GNP (Billions 1965 $US)	1,069.5	5,762
GNP/Cap (Thous. 1965 $US)	1,232	4,580
Less Developed World		
Population (Millions)	2,267.9	4,777
GNP (Billions 1965 $US)	306.7	1,589
GNP/Cap (Thous. 1965 $US)	135	325
World Total		
Population (Millions)	3,348.8	6,389
GNP (Billions 1965 $US)	2,116.8	10,848
GNP/Can (Thous. 1965 $US)	631	1,696

[a]Kahn and Wiener, *The Year 2000,* pp. 142, 143, 157, 159 and 161

Coupled with this phenomenal increase in personal expenditures and reinforcing its potential impact on the environment, is a large projected increase in leisure time. It is conceivable that the 30-hour work week could become the rule by the year 2000. On an annual basis, the hours worked could decrease from 2,060 to 1,528. This represents an average reduction for all sectors of the

economy of about one-quarter in thirty years. This is equivalent to more than one day a week, assuming an eight hour day. If these projections were realized the result would be an enormous demand for more ways to occupy leisure time. These could range from more recreational activity to more years of formal education.

Table 3[a]

Summary of Key Economic Projections
Canada 1967 – 2000

	1967	1980	2000
1. Population (Millions)			
High	–	27.1	41.6
Medium	20.3	25.4	33.8
Low	–	24.8	30.3
2. Gross National Product (Billions $1967)			
High	–	131.9	407.9
Medium	65.5	117.5	307.5
Low	–	112.5	288.1
3. GNP/Capita (Thousands $1967)			
High	–	5,300	12,200
Medium	3,200	4,700	9,200
Low	–	4,500	8,600
4. Personal Disposable Income (Billions $1967)			
High: D-67	–	87	268
Medium: D-67	43	77	189
Low	–	67	144
5. Per Capital Personal Disposable Income (Thousands $1967)			
High: D-67	–	3,500	8,000
Medium: D-67	2,100	3,100	5,700
Low	–	2,700	4,300
6. Personal Expenditures on Goods and Services (Billions $1967)			
High: D-67	–	82	254
Medium: D-67	39	73	179
Low	–	66	138
7. Per Capita Personal Expenditures (Thousands $1967)			
High: D-67	–	3,300	7,600
Medium: D-67	2,000	2,900	5,400
Low	–	2,600	4,100

[a]Compiled from Systems Research Group, *Canada: Population Projections to the Year 2000* (Toronto, 1970), and S.R.G., *Canada: Economic Projections to the Year 2000* (Toronto, 1970). D-67 indicates that the projection assumes that the 1967 distribution of components making up the GNP is maintained through to 2000. The low projection for "personal disposable income", "per capita personal disposable income", "personal expenditure on goods and services", and "per capita personal expenditures" assumes an increasing shift of components from private to public expenditure through to 2000.

The trend toward an increasing stock of education in the population is well underway. The proportion of the 18-24 year-old population in university is expected to rise from 5 per cent in 1955-56 to 20 per cent in 1975-76 and approximately 25 per cent in 2000.[13] The impact of this on environmental management could be greatly increased by the coincidental growth of sophisticated, high-speed communications media, from satellite television to instant worldwide transmission of digital and visual information.

Although one can speculate at length on the precise implications of these trends, there seems little doubt that they have already stimulated a greater awareness of the possible significance of uninterrupted population growth and sharpened sensitivities about urban ugliness, congestion and blight. In the future, higher general education levels coupled with a shift toward nationally and internationally-oriented media, could facilitate public and private measures to protect and enhance environmental quality. Or, conceivably, it could make such intervention more difficult by sharpening conflicts of interest, or by broadening the perceived gap between what appears necessary and what appears feasible.

As the following chapters will show, a major component of increased economic growth will stem from the expansion of industries that at present are pollution-intensive and from activities that at present ravage the environment. In fact it is becoming overwhelmingly evident that a condition of future growth in Canada, as in the rest of the world, is that means be found to control and reduce the negative effects of growth. Failure to do so could mean either a much slower growth than forecast or, conceivably, attainment of the forecast growth until the environment is destroyed. It is unlikely that civilization as we know it will reach the turn of the century if current trends are simply allowed to continue.

A significant modification of these trends will probably require that an increasing proportion of the nation's product be shifted into the purchase of "public goods". Depending upon the strategies adopted, this may be accomplished through the public sector, or the private sector, or both. "Environmental goods" such as clean air, soil and water, pleasant neighborhoods, parks and safe transportation have traditionally been provided through the public sector. If this continues, it would involve a gradual decrease in the proportion of the nation's product available for private expenditure and a corresponding increase in public expenditure. On the other hand it is conceivable that in the future a larger proportion of the costs of a clean and healthy environment could be paid for through corporate and private expenditures. Strategies that involved transferring a larger part of the burden of industrial pollution to the producer would be reflected in higher costs of goods and services purchased by private expenditures. Moreover, current thinking suggests that inducing or compelling producers to

[13]Economic Council of Canada, *Fourth Annual Review* (Ottawa, Queen's Printer, 1967), p. 69 (hereinafter referred to as E.C.C., *Fourth Annual Review).* Estimates for the year 2000 are from information provided by the Systems Research Group.

anticipate environmental costs, and to take them into account when production and marketing decisions are made, could result in more efficient and effective control of waste discharges into the environment.

Looking back over these global projections, one cannot help but wonder about the future of man and his environment. The provision of food, water, minerals, energy, outdoor recreation and other necessities for such vast numbers of people commanding a relatively high purchasing power will place enormous pressures on every corner of the biosphere. There will be no slackening of the growing appetite of the more developed nations, and colossal demands are certain to occur in the less developed regions. A century ago, for example, the production of crude petroleum was negligible. By 1966 it amounted to 1,641 million metric tons per year, having increased sixfold over the preceding 30 years. In the same three decades, world production of motor vehicles grew from 5 million to 19 million per year. Between 1956 and 1966, the total value of all industrial production doubled.[14] Looking to the future, it is estimated that the world will consume more energy in the next 20 years than in the last 100. World food production must increase by 50 per cent over the next 20 years to keep pace with growing populations. Moreover, it is estimated that the world will consume more metals in the next 35 years than it has in the last 2000. World projections for 20 metals are reproduced graphically in Figure 3.[15]

Some experts frankly doubt the ability of the biosphere to withstand these pressures and freely predict ecological disaster. Others fear the inertia of governments and people and question their ability to perceive and respond in time. U Thant, Secretary General of the United Nations, said recently:

> I do not wish to seem over-dramatic, but I can only conclude from the information that is available to me as Secretary General that the Members of the United Nations have perhaps 10 years left in which to subordinate their ancient quarrels and launch a global partnership to curb the arms race, *to improve the human environment,* to defuse the population explosion, and to supply the required momentum to world development efforts.[16]

One does not have to share these conclusions to agree that *if one assumes a continuation of existing growth trends* and, more significant, *if one assumes no change in the balance of technology,* the prospects for man and his life-supporting environment are indeed bleak.[17] Catastrophic deductions can be made

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[14] 47 U.N. ECOSOC, *Problems of the Human Environment,* p. 5.

[15] Commission on Marine Science, Engineering and Resources, *Report*: *Our Nation and the Sea* (Washington, U.S. Govt. Printing Office, 1969), p. 83.

[16] From an address by U Thant to the opening session of the Conference on the Second United Nations Development Decade, May 9, 1969 (emphasis added).

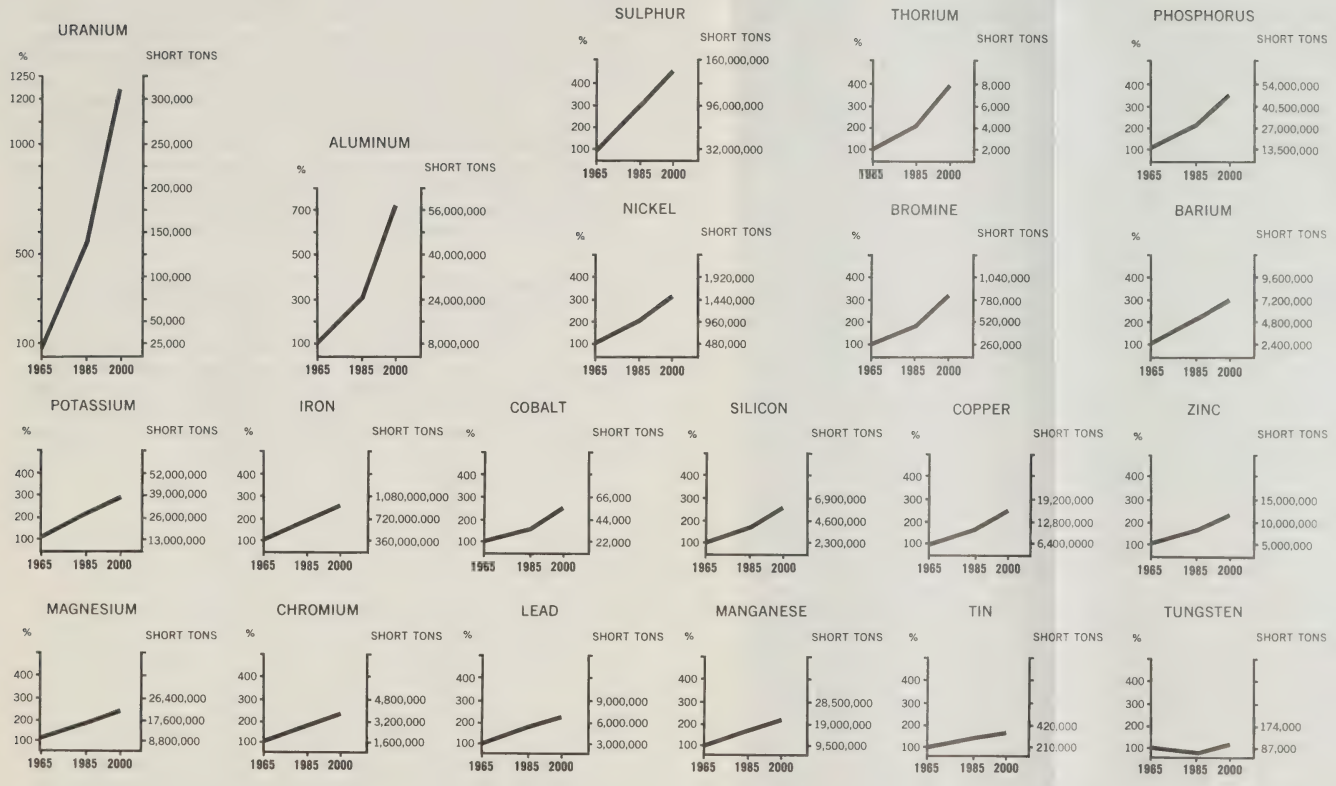
[17] 47 U.N. ECOSOC, *Problems of the Human Environment,* p. 4: "It is becoming apparent that *if current trends continue,* the future of life on earth could be endangered." (Emphasis added). See also J. Platt, "What We Must Do", *Science* (Nov. 28, 1969), p. 1115.

FIGURE 3

PROJECTED DEMAND FOR GIVEN MINERALS TO 1985 AND 2000

PERCENTAGE CHANGE IN OUTPUT FROM 1965

TONNAGE AND PERCENTAGE FIGURES ARE WORLD TOTALS



Compiled from Commission on Marine Science, Engineering and Resources, Report: Our Nation and the Sea (Washington, U.S. Gov't. Printing Office, 1969), p. 85.

from many of the preceding projections, but one of the most explicit is the potential heating of the biosphere by waste heat from projected conventional and nuclear energy production. It has been estimated that if the energy present in the biosphere (almost all of which is due to solar heating) were increased by one per cent, it could have a serious effect on the world's climate. Currently the energy released by man into the biosphere, primarily from the burning of fossil fuels, amounts to about 0.01 per cent of energy input to the biosphere from the sun. If world energy demands continue to grow at their present rate of about four per cent per year,[18] the one per cent limit would be reached about the year 2080. If, however, the "less developed" nations were to grow industrially at a rate that would bring them near to the United States level of per capita energy consumption in about a century, an annual increase in energy consumption of seven per cent would be necessary. This would mean that the danger zone of one per cent of the solar energy input would be reached around 2035.[19] Because of the magnitude of this potential heat loss, many ecologists have concluded that full scale industrialization of the planet, employing present technology, could be disastrous.

Although some authorities may not share the gloomy implications of the above analysis, all will agree on the need to intervene and *modify current trends* through more research and more effective planning and regulation of world resources. It is evident that in the future more intervention will have to be taken at the international level. There are an increasing number of environmental problems that stem from growth pressures external to Canada or, conversely, that reflect spillovers from Canada into other foreign jurisdictions. Either way, in a federal state, they are beyond the sole ability of a province or urban region to resolve.

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[18] Organization for Economic Co-operation and Development, *Energy Policy* (Paris, 1966), pp. 41-42.

[19] Private communication with A. C. Byram, Privy Council Office, Ottawa, July 23, 1970. His calculations agree with those presented in David J. Rose and Melville Clark, Jr., *Plasmas and Controlled Fusion* (Boston, Massachusetts Institute of Technology Press, 1961), p. 3. See also Alvin M. Weinberg, "Application and Research: Nuclear Energy and the Environment", *Bulletin of the Atomic Scientists* (June, 1970), p. 69.

Chapter V

Urbanization and Industrialization

The effects of these environmental pressures on man are both magnified and reinforced by the accelerating concentration of people and industry into urban areas.[20] The relevant global figures on urbanization are displayed in Figure 4. They reveal that between 1920 and 2000, the world's total population could triple; its rural population could double, but its urban population could increase ninefold. In the more developed regions, urban areas contained only 260 million in 1920. This increased to over 500 million by 1960 and could exceed one billion by 2000. The most phenomenal increase, however, could occur in the less developed regions. Their urban population amounted to only 100 million in 1920, but had surpassed 400 million by 1960, and may reach nearly two billion by the year 2000 – a twentyfold increase in 80 years!

Figures on past and projected urban growth in the United States and Canada are equally startling, as shown in Figures 5 and 6. In the United States, between 1850 and 1900, the urban population increased tenfold to 30 million. Fifty years later, 60 per cent of the American population, nearly 90 million people, lived in urban regions. By the year 2000, this could reach 260 million, an increase of 170 million urbanites in 50 years. At that time, 85 per cent of Americans would live in urban regions.

The Economic Council of Canada has noted that the process of urbanization was somewhat slower to develop in Canada than in the older industrialized countries.[21] In the post-war period, however, Canada has experienced a higher rate of urban growth than any other developed country. Although a majority of Canadians have lived in urban areas since the early 1920's, the absolute increases in our urban population were small prior to 1951. Between 1951 and 1966, however, urban regions absorbed almost all of our total population increase of

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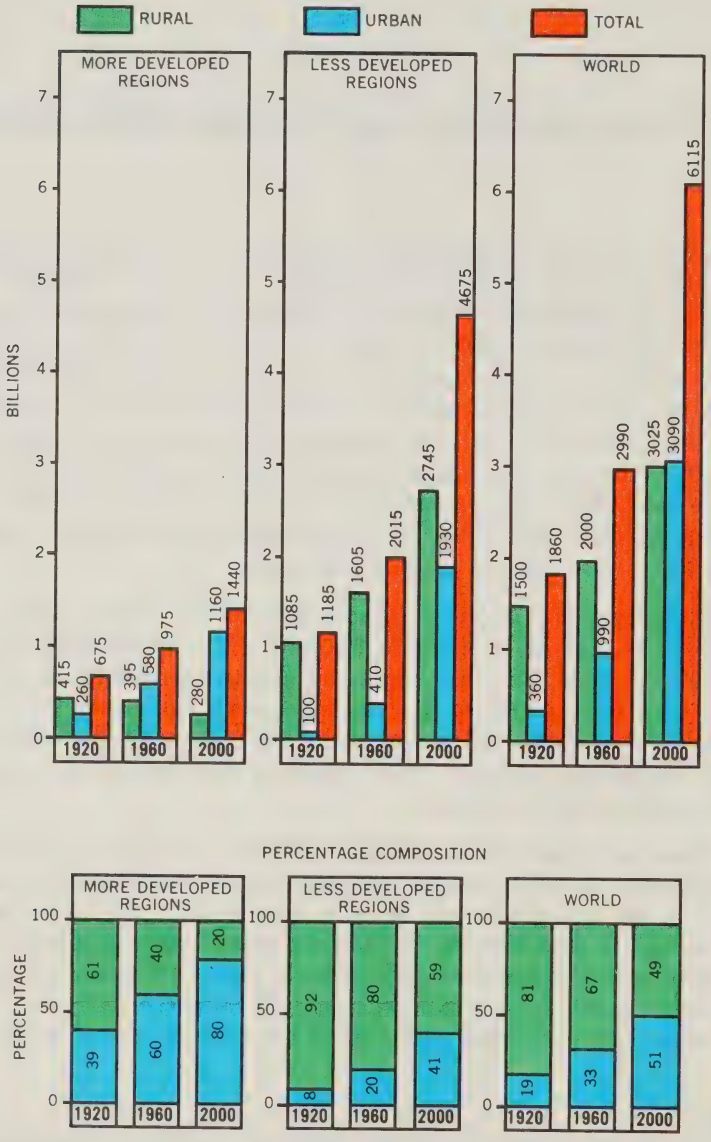
[20] See E.C.C., *Fourth Annual Review,* pp. 173-225 for a discussion of the mutually interacting forces underlying urbanization, including the forces of population and economic growth, industrialization and technology considered here.

[21] E.C.C., *Fourth Annual Review,* p. 180.

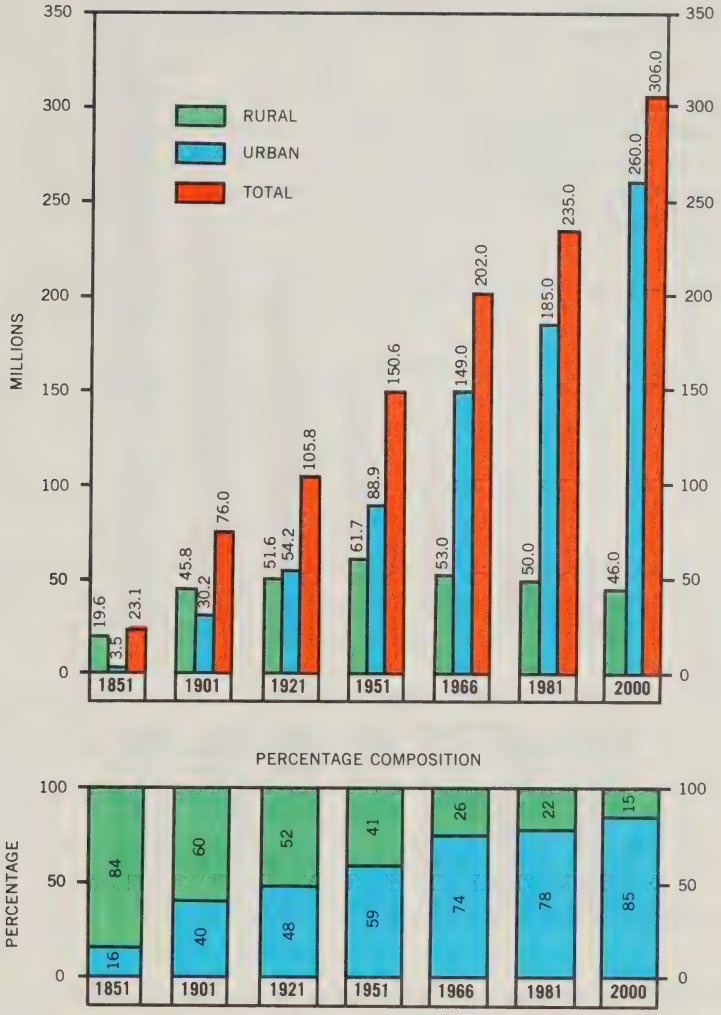
FIGURE 4

WORLD TOTAL, RURAL AND URBAN POPULATION ESTIMATES AND PROJECTIONS: 1920-2000 (BILLIONS)



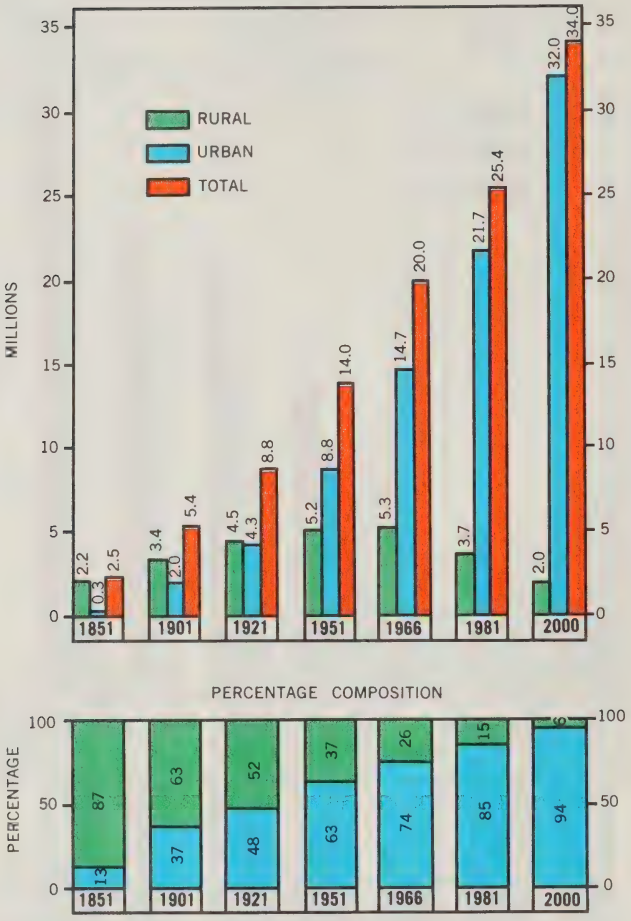
Compiled from 15 U.N. ECOSOC (Pop. Comm.), World Population Situation, p. 44.

FIGURE 5
UNITED STATES, TOTAL, RURAL AND URBAN POPULATION
ESTIMATES AND PROJECTIONS: 1851-2000



Compiled from: U.S. Department of Housing and Urban Development, "Trends and Projections."

FIGURE 6
CANADA TOTAL, RURAL AND URBAN POPULATION
ESTIMATES AND PROJECTIONS 1851-2000



The 1851-1921 data are from Historical Statistics of Canada, M.C. Urquhart and K.A.H. Buckley, eds. (Toronto, MacMillan, 1965), p. 14. The 1951 estimate is from E.C.C., Fourth Annual Review, p. 178. The 1966 data are from D.B.S., 1966 Census of Canada: Population, Rural and Urban Distribution, I (1-8) (Cat. 92-608, March, 1968), p. 13-1. Projections for 1981 and 2000 are from Systems Research Group, Canada: Population Projections to the year 2000 (Toronto, 1970).

6.0 million people. Between 1951 and 1961, urban growth averaged 4.1 per cent each year. Among the developed nations, the next highest rate during this period was 2.7 per cent in the United States.[22]

The figures suggest that we can expect a somewhat lower overall rate of urban growth during the next thirty years although in absolute terms the figures are impressive. Between now and 2000, Canada's urban population could more than double from around 15.0 million to 32.0 million. If we experience the higher rate of population growth shown in Table 1, our urban population could jump two and one-half times to 39 million. During this period, Canadians will have to plan and develop enough urban area to accommodate this population as well as replace much of their existing urban plant as it becomes obsolete. This is a staggering prospect, but it is also a great opportunity; Canadians have the choice of developing their new urban regions and redeveloping most of their existing ones in harmony rather than in conflict with man and his environment. Urbanization will be examined more fully in Part Three.

By and large these national trends apply to all of the provinces and regions of Canada. Projecting provincial population is hazardous, because of the uncertainties of internal migration. Even on a national basis, the year 2000 projections show a range of about plus or minus 5 million or 15 per cent. Nevertheless, provincial projections have been attempted and are displayed in Appendix 2.[23] A regional summary of the appendices is set out in Table 4.

Regional concentration is a corollary of urbanization. Under the "medium" assumptions, the provinces sustaining the highest rates of population growth between 1966 and 2000 would be British Columbia, Ontario, Alberta and Quebec, in that order. British Columbia's share of the nation's population would jump from 9.4 per cent in 1966 to 14.1 per cent in 2001. The Prairie Provinces would drop from 17.0 to 13.0 per cent; Ontario's share would rise from 34.8 to 39.7 per cent; Quebec's would fall from 28.9 per cent to 27.0 per cent; and the Atlantic Provinces would drop from 10.0 to 6.2 per cent. In 1966, all provinces except Prince Edward Island and Saskatchewan had a majority urban population. The most highly urbanized were Ontario, Quebec and British Columbia in that order. By the turn of the century, Quebec may be Canada's most urbanized province, and all provinces except Prince Edward Island are likely to be more than 80 per cent urban.

Traditionally, the process of urbanization has been seen to involve mainly the movement of people from rural areas into towns and cities. An important feature of urbanization today, however, is the movement of people from urban

[22] *Ibid.*, p. 177.

[23] Appendix 1 shows the growth of total, urban and rural population by province for the years 1901, 1921, 1951 and 1966. Appendix 2 shows the projected growth by province at 1981 and 2000. Three projections are given, high, medium and low, bracketing a range of possible fertility, mortality and external and internal migration assumptions.

Table 4[a]

Growth of Total, Urban and Rural Population
Canada and Its Regions
1966 – 2000

	1966			1981			2000		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Canada									
Medium	20.0	14.7	5.3	25.3	21.7	3.7	33.8	31.8	2.0
% Canada	*100*	*73.6*	*26.4*	*100*	*85.4*	*14.6*	*100*	*94.1*	*5.9*
High	–	–	–	27.1	23.2	3.9	41.6	39.1	2.5
Low	–	–	–	24.8	21.2	3.6	30.3	28.5	1.8
Atlantic Region									
Medium	2.0	1.1	0.9	2.1	1.4	0.7	2.1	1.7	0.4
% Canada	*10.0*	*5.5*	*4.5*	*8.3*	*5.5*	*2.8*	*6.2*	*5.0*	*1.2*
% Region	*100*	*55.0*	*45.0*	*100*	*66.9*	*33.1*	*100*	*81.2*	*18.8*
High	–	–	–	2.3	1.5	0.8	2.7	2.2	0.5
Low	–	–	–	2.0	1.3	0.7	1.8	1.5	0.3
Quebec									
Medium	5.8	4.5	1.3	7.3	6.5	0.8	9.1	8.8	0.3
% Canada	*28.9*	*22.5*	*6.5*	*28.6*	*25.7*	*3.2*	*27.0*	*26.0*	*0.9*
% Province	*100*	*78.3*	*21.7*	*100*	*89.4*	*10.6*	*100*	*96.4*	*3.6*
High	–	–	–	7.6	6.8	0.8	10.5	10.2	0.3
Low	–	–	–	7.1	6.4	0.7	8.2	7.9	0.3
Ontario									
Medium	7.0	5.6	1.4	9.3	8.3	1.0	13.4	12.8	0.6
% Canada	*34.8*	*28.0*	*7.0*	*36.8*	*32.8*	*4.0*	*39.7*	*37.9*	*1.8*
% Province	*100*	*80.4*	*19.6*	*100*	*89.1*	*10.9*	*100*	*95.6*	*4.4*
High	–	–	–	10.1	8.9	1.2	17.0	16.3	0.7
Low	–	–	–	9.2	8.1	1.1	12.1	11.5	0.6
Prairie Region	3.4	2.1	1.3	3.9	3.1	0.8	4.4	4.1	0.3
% Canada	*17.0*	*10.5*	*6.5*	*15.4*	*12.2*	*3.1*	*13.0*	*12.1*	*0.9*
% Region	*100*	*61.9*	*38.1*	*100*	*79.6*	*20.4*	*100*	*93.2*	*6.8*
High	–	–	–	4.3	3.4	0.9	6.0	5.4	0.6
Low	–	–	–	3.8	3.0	0.8	3.9	3.5	0.4
British Columbia									
Medium	1.9	1.4	0.5	2.8	2.4	0.4	4.8	4.4	0.4
% Canada	*9.4*	*7.0*	*2.5*	*11.1*	*9.5*	*1.6*	*14.1*	*13.2*	*1.2*
% Province	*100*	*75.3*	*24.7*	*100*	*84.4*	*15.6*	*100*	*92.5*	*7.5*
High	–	–	–	2.9	2.4	0.5	5.3	4.9	0.4
Low	–	–	–	2.7	2.3	0.4	4.3	4.0	0.3

[a]1966 data are taken from D.B.S., *1966 Census of Canada: Population, Rural and Urban Distribution,* I(1-8) (Cat. 92-608, March, 1968). Projections are compiled from Systems Research Group, *Canada: Population Projections to the Year 2000* (Toronto, 1970).

areas into a few large urban regions. This feature is of special consequence for environmental management and has significant implications for the role of different orders of government in a federal state.

This characteristic is also universal. "Around 1800 there were only 22 cities in the world containing a population of 100,000 or more. By 1900 there were

more than 800 cities of this size."[24] According to the U.N. Population Commision, "Big cities of the world (with at least 500,000 inhabitants) numbered 158 in 1950 and 234 in 1960 and the number of multi-million cities increased from 20 to 26. . . . It is noteworthy that an increasing proportion of the urban population is that of the big cities, despite the continuing emergence of numerous new urban settlements."[25]

These universal characteristics dominate the Canadian population pattern. Between 1961 and 1966, urban areas with a population of 100,000 or more grew at almost twice the rate of our smaller cities and towns. In 1970 there were 25 cities with an estimated population in excess of 100,000. By the year 2000 perhaps 70.0 per cent of the total Canadian population – 23.8 out of 34.0 million – will live in 36 such centres. More than 60 per cent of Canadians, around 20.0 million, could live in 15 centres with populations of 300,000 or more. And one-half, 17.0 million, could reside in only nine centres, each approaching or exceeding the 1.0 million mark.

Over the next three decades, then, a sizeable proportion of the world's population and the overwhelming majority of Canadians will come to reside in larger urban regions. It is within these regions that most of our rapidly expanding incomes will be earned and most of our goods and services will be produced and consumed. As we shall see in succeeding chapters, this could result in a staggering increase in fuel consumption, in the use of raw materials of various kinds, in goods transportation and other services and in demand for water for domestic, cooling and processing purposes. In the absence of measures to guide technology, this would result in a corresponding increase in noise, air, soil and water pollution and in solid wastes.[26] These wastes, too, would be concentrated initially in our large urban regions, and it is a practical certainty that neither the human nor the physical components of our urban eco-systems could withstand such pressures. Fortunately, we do not have to assume that technology will continue to be unguided; we have a choice.

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[24] E.C.C., *Fourth Annual Review*, p. 176.

[25] 15 U.N. ECOSOC (Pop. Comm.), *World Population Situation*, p. 142.

[26] An unguided technology works both to increase and decrease levels of pollution. In the past it has worked more to increase than to decrease environmental deterioration and there is no reason to believe that it would be any different in the future.

Chapter VI

Research and Technology

Given the foregoing projections one could not help but be pessimistic were it not for man's increasing knowledge and the power of technology. Indeed, it would be difficult to overestimate the importance of research and technology to environmental management.

On the one hand, the application of research and technology is a root cause of most of the existing or emerging environmental problems discussed above. By eliminating epidemic disease and increasing food production, research and technology made possible the rapid rise in world population. They are also the principal source of economic growth. "In the late 1950's several excellent studies began to indicate that some 90 per cent of all productivity increases and 70 per cent of measured economic growth in the United States over the preceding 35 to 50 years could be attributed to technological advance. . . ."[27]

On the other hand, research and technology can provide solutions to many of society's environmental problems. There is little doubt that research, if properly guided, can provide technological answers to the technological aspects of these problems. Given recent developments in social sciences, there is reason to hope that research can also provide answers to the social, political and institutional aspects.[28]

It will take more than mere faith in research and technology to achieve this potential, however. It will require an increasing degree of careful guidance within a broad framework of provincial, national and international policy objectives.

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[27] James B. Quinn, "Technology Transfer by Multinational Companies", *Harvard Business Review*, LXVII (Nov.-Dec., 1969), p. 148. The author is referring to the *"technological application* of land, labour, capital and education" (emphasis added). He also no doubt views "economic growth" as we currently measure it, ignoring its negative spillovers and social costs. The author quotes three sources for this statement: I.R. Solow, "Technical Changes and the Aggregate Production Function", *Review of Economics and Statistics* (August, 1957); S. Fabricant, "Resources and Output Trends in the U.S. Since 1870", *American Economic Review* (May, 1956) and E.F. Denison, "U.S. Economic Growth", *Journal of Business of the University of Chicago* (April, 1962), p. 116.

[28] See Olaf Helmer, *Social Technology* (New York, Basic Books, 1966), and also J.P. Bruce and D.E.L. Maasland, *Water Resources Research in Canada:* Science Secretariat Special Study No. 5 (Ottawa, Queen's Printer, 1968).

Four characteristics of research and technological innovation have special significance for environmental management. They are their increasing rate of change, scale and impact; their growing institutionalization in both the public and private sectors; their rapid internationalization; and their unregulated development and diffusion. We shall consider each of these briefly and examine its implications for new or revised constitutional arrangements.

INCREASING RATE OF CHANGE, SCALE AND IMPACT

The historic impact of science and technology on man and his world has already been adequately covered. The growing scale of this phenomenon and its almost incomprehensible rate of change are well known but their implications for environmental management are not generally appreciated.

The post-war growth in the number and varieties of new products is often cited as one of the marvels of technology. And it is. Yet each one of these new products is, or eventually becomes, a pollutant – audio, visual, solid, liquid or gaseous. We boast that more than half of the sales made by some of our major corporations involve products that were not on the market ten years ago, forgetting that most of these potential polluters entered the market without adequate assessment directed to the public interest.

Even in fields where public supervision is now required, adequate control is, for several reasons, becoming increasingly difficult and expensive. The rate of increase of new products is one reason. Another is the fact that increasing combinations of products have a greater total effect on the environment than a simple summation of the effects of each product would suggest. This intensifies the problem of devising adequate tests to anticipate and assess all possible impacts on man and his environment. A third reason is that many products originate outside Canada and their design, production and marketing are beyond direct domestic control.

The production and use of organic chemicals illustrate these problems. Nearly 500,000 organic chemicals have been produced since World War II, most of them synthetically. Hundreds of them are present in treated water supplies at low concentrations but we do not know what chemicals are present or in what concentrations. Chronic toxicity tests are very expensive, as high as $50,000 to $250,000 per compound, and there is an acute shortage of specialists in toxicology.[29] Other examples could be cited in the field of pharmaceutical drugs, plastics – even ornamental jewellery and children's toys.

These problems promise to become even more pressing in the future. The Hudson Institute and RAND Corporation in the United States have identified a

[29] O.C. Herfindahl and A.V. Kneese, *Quality of the Environment* (Baltimore, Johns Hopkins Press, 1965, printed for Resources for the Future, Inc., Washington), p.17.

large number of technological innovations that could occur over the next three decades.[30] More recently, the Science Council of Canada has added to this important field of technological forecasting by publishing the results of a small study undertaken in Canada.[31] Many of the innovations cited in these studies could have a significant impact on the management of the urban, national and global environment, as well as on other areas of public policy. They include new methods to control birth and sex and to postpone aging; economical methods to reduce and dispose of wastes; powerful techniques to survey and study land, water and air resources, to regulate their development and use and to monitor their quality; new methods to construct artificial environments and to employ leisure time; and rather frightening possibilities for what might be called human and political management.

Some of these forecasted innovations are awesome in their implications, confirming that we live in an incredible world in which virtually anything is possible if man applies his intelligence and resources to it. Some promise exciting solutions to environmental and other problems. Others could result in further deterioration of the environment. Still others raise fundamental moral and ethical issues. Some of them lead one to ask whether public policy might better discourage research and innovation in certain areas. They raise questions of over-centralization, internationally as well as nationally; of developments spanning too many jurisdictions to be compatible with meaningful local autonomy or even national sovereignty; of excessive governmental and/or corporate power over the environment, the economy or individuals; of loss of privacy; and of changes too rapid or cataclysmic to permit human adaptation.[32]

These are large questions but they cannot be avoided. They will be answered in the coming years, if not explicitly, then implicitly; if not by action, then by default. The answers will largely determine the character and quality of man's environment.

INSTITUTIONALIZATION OF RESEARCH AND TECHNOLOGY

Most of the technological innovations that shaped man's environment during the first half of this century originated largely from inspired genius working in relative privacy with limited funds. The telegraph, telephone, internal combustion engine, automobile and manned flight are examples. Although each has had a profound impact, they occurred as individual inventions and were applied over a relatively extended period of time.

Today, research and development is a major industry, carefully nurtured and generously supported by government and corporate business alike. It is carried out

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[30] Kahn and Wiener, *The Year 2000*, pp.51-55, and see Olaf Helmer, *Social Technology*, pp.64-78.

[31] Science Council of Canada, *Thoughts* (April, 1970), pp.23-24 (staff magazine).

[32] Kahn and Wiener, *The Year 2000*, p.51.

in large institutions. These are located in three sectors – government, industry and university – but they are funded mainly by two – government and industry.

The great bulk of public funding is provided by the national government. This is true in Canada and in other major federal countries, particularly the United States and West Germany.[33] Most private industrial research is supported and undertaken by industries dominated by large national and multinational corporations. In Canada 67 per cent of all industrial research and development expenditures were made by the construction machinery, transportation equipment, electrical products, chemical and petroleum industries. Of the balance, 16 per cent was undertaken in the paper and primary metals industries. It will be observed that all of these industrial sectors are pollution-intensive. Moreover, private research and development tends to be concentrated in a small number of large companies.[34]

INTERNATIONALIZATION OF RESEARCH AND TECHNOLOGY

Most nations recognize that they cannot themselves develop all of the research and technology they need for all their purposes. Nor can they achieve modern living standards or compete successfully on the basis of their own technology and markets. As a result, in respect of that part of their research and development effort under direct public sponsorship and control, most nations are moving in two broad directions. First, they are setting up bodies to advise them where to concentrate their own precious scientific and technological resources for maximum impact, and to recommend how best to import and apply that research and technology they cannot or should not support and develop themselves.[35] Second, through the specialized agencies of the United Nations, OECD, and other international bodies and through bilateral arrangements, they are endeavouring to facilitate the exchange of scientific knowledge and to cooperate in allocating research efforts.

Political boundaries are largely irrelevant to the transfer and diffusion of scientific knowledge. Within the public sector policies at the national and, as just mentioned, at the international level are generally designed to encourage exchange of knowledge. Within the private sector, the internationalization of research and development is proceeding in pace with the growth of large, multinational companies. This has particular significance for Canada.

It is impossible to say how many companies fall into the general category of what are variously described as "multinational" or "international" or "world"

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[33] See J.L. Orr, *Statistical Data On Industrial Research and Development in Canada* (Ottawa, Queen's Printer, 1967), Table 2. The other countries surveyed included the U.K., Netherlands, France, Japan, Sweden and Belgium.

[34] *Ibid.*, Tables 2,5,6,9.

[35] Note especially the Science Council of Canada and its counterparts in the U.S. and the United Kingdom.

corporations. It depends on the definition and the measures employed. One estimate places the number at 150, half of which are U.S. based. "About $400 billion worth of goods are currently produced under international investment and about half of this is U.S. originated."[36] Another estimate suggests that international companies are producing $300 billion a year outside their home countries.[37] These figures are astronomical; to put them in perspective, one may recall that the value of world trade in 1967 was $214 billion. In other words, the value of goods produced by multinational corporations outside their home countries approaches or exceeds the value of world trade. To view it from still another perspective, "The foreign production of these corporations alone now forms in aggregate, the third largest economy in the world, following only the domestic economies of the United States and the Soviet Union."[38]

This sector of the world economy is not only strong but it is also growing at an extremely rapid rate. "Over the past two decades . . . international investment and its output have been growing about twice as fast as world GNP. By the end of this century, if the growth of world GNP continues at the pace of the 1960's and output associated with international investment maintains its faster rate, the world economy will be more than half internationalized."[39]

The competitive potential of world corporations is so great that some authorities think that in the future a few hundred such companies could dominate world economic, research and technological development. They argue that the multinational company is by far the most effective vehicle for the dissemination of scientific knowledge and the application of technology, because of its world wide research organizations and marketing units as well as its centralized authority structures, communication systems, and resources needed to bring technological solutions found in one geographical area to bear on a problem or opportunity identified in another.[40]

The future development of multinational corporations will have far-reaching consequences for environmental management and for other areas of public policy. They will be the source of an increasing volume and variety of products with side effects that threaten man's health and impair the quality of his environment. Many of these side effects can be controlled most effectively

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[36]Judd Polk, "The Rise of World Corporations", *Saturday Review,* LII (Nov. 22, 1969), p.32.

[37]Christopher Tugendhat, "International Firms Face Executive Problems", *Globe and Mail,* Dec. 27, 1969, p. B-3. See also Sanford Rose, "The Rewarding Strategies of Multinationalism", *Fortune* (Sept. 15, 1968), p.100.

[38]Canada, House of Commons, Standing Committee on External Affairs and National Defence, *Minutes of Proceedings and Evidence, No. 9* (Jan. 20, 1970), statement by Professor Abraham Rotstein.

[39]Judd Polk, "The Rise of World Corporations", *Saturday Review,* LII (Nov. 22, 1969), pp.32-33.

[40]James B. Quinn, "Technology Transfer by Multinational Companies", *Harvard Business Review,* LXVII (Nov.-Dec., 1969), p.150.

at the source, in the design office, testing facility, or production line. Some can be controlled only at the source.

Conversely, and for the reasons outlined above, multinational corporations could be the source of technology to resolve many environmental problems and they could be efficient and effective vehicles for the world-wide dissemination and application of that technology. Yet, as a Royal Commission recently noted, "To an important degree, these multi-national corporations are independent of the national authority of individual countries. At the present time, no international authority exists which can exercise authority over them."[41] This has far-reaching implications when one considers the probable future need to subject these corporations to environmental management strategies, either regulatory strategies or strategies designed to induce them to anticipate environmental costs and take them into account in their production and marketing decisions.

UNREGULATED DEVELOPMENT AND DIFFUSION OF TECHNOLOGICAL INNOVATION

In the future, control of many environmental problems will be possible only by subjecting technological innovation to a much greater degree of social planning. Unless the nations of the world perceive this and act in concert respecting it, the future of man and his global habitat may well be in jeopardy. After 50 years, given the trends described earlier, there can be little doubt about the power of an undirected technology to destroy the quality of our environment. There can also be little doubt about the power of research to provide solutions to some of our environmental problems: not only technological solutions but also social, economic, legal and institutional solutions.

Given the influence of science-based multinational companies commanding vast global markets, future environmental control must involve the national application of internationally devised strategies. Many forms of air pollution such as exhaust emissions from automobiles can be controlled effectively only in this manner. Non-degradable containers, phosphate fertilizers, pesticides and many other pollutants fall in the same category. Smaller countries like Canada or even some of the major nations may not be able to enforce certain types of environmental strategies on their own. This may be because the country lacks market leverage, or because the innovation is developed in one country and applied in another that is unaware of its harmful effects. It may be because of international competition. If Canada or the United States permits its pulp and paper industry to escape the costs of pollution control, other exporting countries might be compelled to follow suit or risk higher costs and the loss of markets.

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[41] Canada, Royal Commission on Farm Machinery, *Special Report on Prices of Tractors and Combines in Canada and Other Countries* (Ottawa, Queen's Printer, 1969), p.93.

It seems evident that in the future, positive action will be necessary to influence the direction of technological development. Environmental management will require the development of acceptable national and international mechanisms through which to focus research on environmental and related social problems and to determine how best to develop the resulting technological innovations for the benefit and protection of society. This will be extremely difficult, given the enormous complexity of the issues involved. Many frankly doubt the ability of man to devise and work through such mechanisms considering his nature and the inertia of his institutions.

The evidence of history shows the difficulties. In the past only a small proportion of research and technology has been consciously focused on social goals. When governments, industries and individuals decide to pursue or forego a line of research or an innovation, their decision is usually based on a very narrow assessment of potential gains and losses to themselves.[42] Very seldom has the public or private decision-maker had the incentive, responsibility or authority to project and consider the full range of undesirable as well as desirable consequences that might flow from a decision. Even if he were to do so, a private competitor – or another government – might not. Decision making in this as in most other areas is diffused nationally and internationally throughout the public and private sectors.

This has had two major results. The first is distortion of emphasis in research and development efforts with serious consequences for man and his environment. The five o'clock congestion in our cities, the smog over Montreal, the shame of Lake Erie all represent one end of a chain of reactions induced by thousands of narrow and unrelated technological decisions by public agencies and private companies over the past 50 years. The decision of several governments to develop a supersonic transport provides a more recent illustration of the distortion that can result. Dr. John H. Knowles, Director of the Massachusetts General Hospital, referred to this at the December, 1969 meeting of the American Association for the Advancement of Science when he said, "We are spending twice on the development of supersonic transport what we spend on medical research in one year and that's going to cause more disease, more noise, air pollution and traffic congestion. And who the hell wants to get to London a few hours earlier anyway? "[43]

In the case of many decisions, of course, there have been social benefits which have served to justify and give momentum to the original allocation of

[42] For a discussion of these questions, see Harvey Brooks and Raymond Bowers, "The Assessment of Technology", *Scientific American* (February, 1970), p.13, a report of a panel convened by the U.S. National Academy of Sciences to recommend mechanisms to consider the social consequences of advancing or retarding particular technological developments.

[43] *Time*, Jan. 12, 1970, p.34 (quotation confirmed by the office of Dr. Knowles, July 10, 1970).

funds. The peaceful uses of atomic energy may be an example. It can be argued, however, that the positive benefits would be much greater if the research had been focused directly on the relevant social goals.

Technological decision making within a narrow framework has a second result. It is the failure to pursue lines of research and innovations that could have significant social benefits. This happens when the potential economic or political return from one innovation does not appear as great as that from another to the decision-maker concerned. Because research in some areas appears to lack economic or political appeal, opportunities for social gain are lost altogether or postponed until they occur as an indirect "spin-off" from other programs.

There is perhaps no other area of concern to environmental management where the need to relate available resources to social ends is both so necessary and so difficult as that of research and technology. Man's future may well depend on the ability of the public and private sectors to devise and apply strategies that will result in allocating a much greater proportion of research and development resources to measures to protect and enhance the quality of the global environment. National action is inhibited by the momentum of the forces discussed above. International effort will be required and it may sometimes be easier for smaller, technologically advanced countries like Canada to initiate such effort, than for larger countries to do so.

Chapter VII

General Considerations Respecting the Role of Governments

In the future, the trends and forces discussed above will result in a continual reshaping of commercial, institutional and political relationships within Canada and between Canada and other nations. It is not the purpose of the constitutional review to prescribe *specific* strategies or policies to respond to these trends. Nor is it the purpose of this background paper. Rather its purpose is to examine the emerging trends, to highlight some of the major issues that could arise, and to identify the *range* of strategies that governments *may* have to apply in order to guide and even shape the trends. It is hoped that this will provide a useful contribution to the continuing discussion of a distribution of powers between different orders of government on matters affecting environmental management.

The British North America Act has probably enabled Canadian federal and provincial governments to respond to past environmental problems as effectively as have governments in other federal states. Certain revisions or reinterpretations, however, may make it a more suitable vehicle in the future. Questions concerning three broad areas flow out of the above analysis and will be discussed in turn. They are flexibility, research and international action.

FLEXIBILITY

Constitutional arrangements in a federal state should provide a high degree of flexibility in determining the order of government best able to develop or apply various environmental strategies at different points in time. This stems generally from the fact that the underlying demographic, economic and technological forces giving rise to environmental problems are changing at an increasingly rapid rate. More specifically, it derives from technological uncertainty. Technology can be expected to raise new problems that we cannot now foresee and to alter the character of existing problems.

For governments the corollary of technological uncertainty is flexibility. The character, spatial dimensions and other characteristics of environmental problems will change with time and technology. Some will be most responsive to the application of management strategies at the urban or provincial level. Others will require action at the national and international level. Moreover, as the nature and spatial dimensions of problems change, the order of government in the best position to cope with the problem, or certain aspects of the problem, will also change. It would be useful to consider whether existing governmental arrangements permit the degree of flexibility likely to be required in the future, or whether alternative devices should be examined.

Under the present constitution, the transfer of jurisdiction from one order of government to another has been achieved in various ways, including formal amendments and the use of the declaratory power.[44] The former has obvious limitations and the latter has been criticized on various grounds.[45]

Would it be possible to meet this problem by a form of what might be described as conditional concurrency? Under such a device flexibility would be achieved within a set of concurrent powers by an arrangement under which federal laws could be applied to matters that had been subject to provincial laws when conditions concerning the matter had changed to the point where its effective management required action at the national or international level. *And vice versa.* Such an arrangement would provide that the entry of either order of government into a field of concurrent jurisdiction could be challenged by the other order of government and made subject to judicial review based on criteria set out in the constitution. These might take the form of a provision under which, on any matter that falls within the list of concurrent powers, the Parliament of Canada would have the right to legislate where and to the extent that the matter cannot be dealt with effectively by the provinces. The meaning of "effectively" could be allowed to evolve with changing circumstances, through judicial interpretation. Or, if this were thought to be too uncertain, the provision could include criteria for effectiveness such as the geographical dimensions of the matter (that is, management by a single province might prejudice the interests of another province, the entire nation or another country); or the need for uniform regulations, or the uniform application of standards stemming from national laws or international agreements. Over time, the criteria could be modified or changed by constitutional amendment. In designing this or any other device, of course,

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[44] The British North America Act, 1867, 30 & 31 Vict., c.3, s.92(10)(c).

[45] See Andrée Lajoie, *Le pouvoir déclaratoire du Parlement* (Montreal, Les Presses de L'Université, 1969).

flexibility would have to be reconciled with the need for jurisdictional certainty at any point in time.[46]

A less flexible but more conventional alternative arrangement would provide that concurrent powers over certain matters be subject to federal paramountcy, while concurrent powers over other matters might be subject to provincial paramountcy and concurrent powers over still other matters might be subject to no paramountcy. Matters falling within each category could be changed from time to time by constitutional amendment.

A marked degree of flexibility can be achieved, without a formal transfer of jurisdiction, by delegating the administration of policies and programs from one order of government to agencies of another. It seems important that provisions for intergovernmental delegation be retained. As the later discussion will show, this would permit a much higher degree of functional efficiency in many areas of environmental management.

RESEARCH

The growing scale of research, its institutionalization and its internationalization have tremendous significance for a smaller nation like Canada that wishes to maintain high, technologically-based living standards, a competitive position in world markets, *and* a high-quality physical environment. If these goals are to be achieved, it seems evident that all orders of government have a continuing, vital role to play in initiating, undertaking and sponsoring research, as well as any functions necessarily associated with research, such as information systems within their jurisdiction. They will also have to be in a strong position to influence decisions respecting the national allocation of limited scientific resources.

At the international level, the federal government can expect to be called upon to promote and support measures aimed at the exchange of knowledge and technology, the sharing of research efforts, and, perhaps, the introduction of social considerations into decisions on research and development. Increasingly,

[46]This might be achieved, perhaps, by a provision under which any matter contained within a designated set of concurrent powers would be deemed to fall within the jurisdiction of the provinces, and the legislatures of the provinces would have the authority to legislate as long as and to the extent that: the Parliament of Canada did not use its legislative powers; or that any federal legislation had been rescinded; or that the federal legislation was ruled incompatible with the criteria set out. If water quality management fell under the list of concurrent powers – a possibility discussed in Part Five – a provision of this kind might also avoid the difficulty seen by some of a potentially unlimited extension of federal jurisdiction via every tributary of an interprovincial or international river basin. Under it, the provinces would have jurisdiction over any basin if the Parliament of Canada did not legislate in respect of it, or a matter concerning it, or if it did legislate in respect of it but was unable to persuade the responsible court that the matter was properly federal by application of the criteria.

these measures may be embodied in formal understandings, treaties and other arrangements between nations.

All of this will require a growing effort in many areas such as the funding and support of provincial, national and international research institutions and related information systems. Only through such a continuing effort will Canada be able to maintain access to international research and technology.

INTERNATIONAL ACTION

In the future, international action concerning environmental management will probably have to go well beyond arrangements for research and information systems. This stems from the above analysis which shows that, more and more, technological spillovers will be international in dimension. It stems from the corollary that the primary sources of many of the most significant environmental problems will be found in the design offices, laboratories and production lines of foreign or multinational companies and will be most amenable to strategies applied at the national or international level. It stems, too, from the fact that the pollution of air and water resources is increasingly a global phenomenon. This will be considered in detail in Part Five. It has been touched upon in the foregoing discussion of the ecological perspective and of population and economic growth trends. Indeed, this early discussion demonstrated that pollution of air and water resources could quickly assume dangerous or catastrophic dimensions at the international level. With improved knowledge and techniques, however, it is possible that man will be able to predict such situations in time to take preventive steps to avoid them.

In this context, Canada has a dual responsibility. First, as one of the ten leading members of the world community in human, economic and technical resources, Canada has a major responsibility to provide leadership in anticipating the environmental and other implications of technological innovations, in preventing problems from arising, and in resolving problems that have arisen. Second, as occupant of a very large part of the global ecological system, Canada must be able to respond in concert with other nations to environmental crises and problems. Accepting this, it is difficult to question the continuing need for the federal government to be in a position to initiate, participate in and support international activity outside of Canada, and also to accept and discharge obligations required of it within Canada, as part of an international effort. It is also difficult to question the need for the federal government to retain its power to establish and enforce, either directly or as a part of an international effort, criteria that must be met by any product crossing provincial or international boundaries. In the future, these criteria might relate to any characteristic of the product, not only those that represent a hazard to the health of man but also those that may represent a threat to the safety and quality of the physical and natural environment, including any part of the biological food chain.

Efficiency, national harmony and other considerations may or may not make it desirable for the federal government to accept international obligations in cooperation with provincial governments and, perhaps, to discharge them by delegation to agencies of these governments. It would seem that this would depend upon the nature of any problem, the time available for response, and the evolving structure of federal-provincial institutions.

PART THREE

THE URBAN REGIONS

Chapter VIII

Canadian Urban Growth

The salient features of national population trends have been outlined. From this it is evident that Canada is already predominantly urban and will become increasingly more urban. By the year 2000, over 90 per cent of our population will inhabit less than two per cent of our land mass. Moreover, these Canadians will be concentrated into fewer and larger regions. In Part Three we take a more detailed look at the projected pace and polarization of Canadian urban growth, the possible future dimensions of some urban environmental problems and their significance for the role of government in urban environmental management.

THE PACE AND POLARIZATION

The following map illustrates the general pattern of population concentration that exists in Canada today and is likely to continue over the next few decades. It also shows the major urban centres in Canada and in the adjacent United States. It makes clear that the principal urban regions are located on major inland rivers and lakes, or on the coastline, or in close proximity to our provincial boundaries and the international border. The political geography of the population pattern reveals the importance of interjurisdictional spillovers in Canadian environmental management.

In Table 5 we show the past and possible future growth of our nine largest urban regions whose year 2000 population is expected to exceed 750,000. The footnotes include a list of an additional 28 centres whose century-end population could fall between 100,000 – 750,000. The breadth of the range between the low and high projection given for each city underlines the fact that these are projections for 2000, not predictions.

The projections provide some indication of the possible directions and dimensions of unconstrained urban growth and of the possible range of social choice.[1] The medium projection of our total national population between 1966

[1] Given the assumptions underlying the projections and the strength of the interacting forces involved, the probability is low that public policies would be able to reduce the rate of growth of these regions below that implied by the lowest projections. The probability is also low that public policies could, or would wish to, stimulate the growth of these regions at a rate higher than that implied by the highest projections.

MAP OF CANADA SHOWING ECUMENE

NOTE: R. Gajda analysed the Canadian ecumene and published a detailed map (Geographic Bulletin 1960). The shaded areas are based on the contemporary Canadian ecumene; the zones of permanently established living areas joined by integrated transportation systems. Major changes have occurred since 1960 in the northern sector of the ecumene in response to changes in the economy and transportation systems.

Table 5

Growth of Nine Largest Urban Regions: 1951–2001 (000's)[a, b]

			1981			2001			
Urban Region	1951	1966	Low	Medium	High	Low	Medium	High A	High B
Toronto – Total	1,264	2,158	3,296	3,354	3,476	4,748	5,185	5,805	6,510
% Increase over 1966	–	*71.0*[c]	*53.0*	*55.6*	*61.4*	*125*	*140*	*170*	*202*
Montreal–Total	1,004	2,437	3,470	3,528	3,714	4,684	5,091	5,831	6,324
% Increase over 1966	–	*62.0*	*42.5*	*45.0*	*52.6*	*93.0*	*109*	*139*	*163*
Vancouver–Total	562	892	1,229	1,250	1,329	1,625	1,770	2,064	2,482
% Increase over 1966	–	*58.5*	*37.6*	*40.0*	*49.0*	*81.7*	*98.1*	*131*	*178*
Sub-Total	3,330	5,487	7,995	8,132	8,519	11,057	12,046	13,700	15,366
% Canadian Total		*27.4*	*32.2*	*32.0*	*31.4*	*38.3*	*35.7*	*32.8*	*37.0*
Ottawa-Hull–Total	296	495	699	711	791	942	1,031	1,307	1,616
% Increase over 1966	–	*67.5*	*41.1*	*43.7*	*60.0*	*90.0*	*108*	*164*	*226*
Edmonton–Total	211	401	617	630	712	902	1,001	1,293	1,223
% Increase over 1966	–	*90.5*	*53.7*	*57.3*	*77.5*	*125*	*150*	*222*	*205*
Hamilton–Total	266	449	617	628	649	818	894	997	1,201
% Increase over 1966	–	*69.0*	*37.2*	*40.0*	*44.7*	*182*	*101*	*122*	*167*
Quebec City–Total	297	413	592	602	591[d]	797	868	873	1,178
% Increase over 1966	–	*39.1*	*43.2*	*45.8*	*43.2*	*92.8*	*110*	*111*	*185*
Calgary–Total	156	331	501	511	629	728	807	1,203	937
% Increase over 1966	–	*112*	*51.5*	*54.5*	*90.3*	*120*	*144*	*263*	*182*
Winnipeg–Total	357	509	589	599	676	652	719	974	1,614
% Increase over 1966	–	*42.7*	*15.7*	*17.7*	*32.8*	*28.1*	*41.3*	*91.2*	*318*
Total	4,913	8,085	11,610	11,813	12,567	15,896	17,366	20,374	22,135
% Canadian Total		*40.3*	*47.0*	*46.8*	*46.3*	*52.6*	*51.5*	*48.6*	*53.4*

[a]Rough projections suggest that an additional six regions could fall in the 300,000–750,000 range by 2000. They are Windsor, London, Kitchener-Waterloo, Halifax, Victoria and Oshawa. A further 22 centres could fall in the 100,000–300,000 range: Regina, Saskatoon, Sudbury, St. Catharines, Thunder Bay, Chicoutimi, Saint John, Sault Ste Marie, Sydney, Trois Rivières, Sherbrooke, Belleville, St. John's, Kingston, Moncton, Shawinigan, Lethbridge, Brantford, Guelph, North Bay, Timmins and Newmarket.

[b]Data for 1951 are taken from Leroy O. Stone, *Urban Development in Canada* (Ottawa, Queen's Printer, 1968), p. 278. Figures for 1966 are taken from D.B.S., *1966 Census of Canada: Population, Incorporated Cities, Towns and Villages*, I (1-7) (Cat. 92-607, Oct., 1967). The "low", "medium" and "high" projections for 1981 and the "low", "medium" and "high A" projections for 2001 are compiled from Systems Research Group, *Canada: Population Projections to the Year 2000* (Toronto, 1970). The "high B" projections for 2001 are taken from N.H. Lithwick, *Urban Canada: Problems and Prospects*, a report prepared for the Honourable R.K. Andras, Minister Responsible for Housing, Government of Canada, Central Mortgage and Housing Corporation, Ottawa, 1970. The S.R.G. projections are based upon an essentially extrapolative methodology, assuming different fertility, mortality and migration rates. The Lithwick projection is based upon a structural approach to forecasting: that is, the totals are derived from projections of each major sector in the economy of a given city, assuming that each sector will grow at the same rate in the urban region as nationally, and modifying the results where special knowledge indicates such modification is warranted.

[c]Percentages given in the 1966 column show the percentage increase over 1951.

[d]It will be observed that the "high" projected figure for Quebec City in 1981 is 11,000 lower than the "medium" projection. This stems from the effect of the migration and fertility assumptions employed. The average of the 1956-66 migration figures used for the "high" projections were high on a national basis but not for Quebec. The high fertility assumption influences the projected population for the younger age groups between 1971 and 1981 and ultimately results in the larger figure for the "high A" estimate of the population of Quebec City in 2001.

and 2000 is 14.0 million. Table 5 suggests that the nine largest cities could absorb two-thirds of this growth and account for half our total population by 2000.

In many cases, because of initial advantages vis-à-vis national and international commodity flows and markets, major centres have been able to achieve self-generating expansion. This is true of our three largest centres, Toronto, Montreal and Vancouver, which today account for one-quarter of the population of Canada.[2] By year 2000, one-third of all Canadians could live in these three urban regions. Based upon the medium projection, they alone would absorb 46.7 per cent of our total national growth and increase their combined populations by 6.5 million or 120 per cent.

Relating Table 5 to the map and looking first at central Canada, we see that both Montreal and Toronto could at least double their 1966 population by 2000. Indeed, they might triple it, each reaching between five and six million people. Together, they would contain nearly 30 per cent of Canada's population. Both cities would dominate their respective provinces, with Montreal containing between 55 and 65 per cent of Quebec's population and Toronto between 35 and 45 per cent of Ontario's.[3]

Montreal and Toronto also form part of an urban system of 21 centres stretching along the lower Great Lakes and the St. Lawrence from Windsor to Quebec City. The cumulative year 2000 population of these centres has been projected at nearly 16.0 million, almost 50 per cent of Canada's total population and over 65 per cent of the combined population of Quebec and Ontario. They also form part of an international urban network sharing basic water, air and land resources, resources which provide a habitat for a significant component of North America's food chain and life support system.[4] American cities around the lower Great Lakes expect a combined increase of 18.7 million over the next thirty years, from 40.4 million to 59.0 million.[5] Cities along the Atlantic seaboard could have a

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[2] This is supported by the analysis and data in N.H. Lithwick, *Urban Canada: Problems and Prospects,* a report prepared for the Honourable R.K. Andras, Minister Responsible for Housing, Government of Canada, Central Mortgage and Housing Corporation, Ottawa, 1970 (hereinafter referred to as N.H. Lithwick, *Urban Canada: Problems and Prospects*). Forecasts prepared for N.H. Lithwick by I. Lithwick employing projections developed by the Systems Research Group, suggest that by 2000 Montreal could generate over 14 per cent of Canada's GNP, Toronto about the same and Vancouver nearly 5 per cent. The nine major cities could together generate nearly 50 per cent.

[3] See Table 3 and Appendix 2 for a summary of provincial projections.

[4] See *The International Megalopolis* (Eighth Annual University of Windsor Seminar on Canadian-American Relations), Mason Wade, ed. (Toronto, University of Toronto Press, 1969).

[5] This includes the Chicago-NW Indiana, Detroit-Ann Arbor and Cleveland-Lorrain complexes, as well as Pittsburgh, Cincinnati, Milwaukee, Buffalo, Indianapolis, Columbus, Dayton and Rochester. From U.S. Dept. of Housing and Urban Development, Technical Paper No. 4, "Trends and Projections of Future Population Growth in the United States, with Special Data on Large Urban Regions and Major Metropolitan Areas for the Period 1970-2000", p.16.

combined increase of 21.6 million, from 45.8 to 67.4 million.[6] Thus the projected thirty-year population increment of American cities adjacent to Ontario, Quebec and the Maritimes is three times that projected for Canada as a whole. Considering this within the context of the economic, technological, leisure time and other trends discussed in Part Two, it seems evident that the spillovers from this external growth upon Canadian ecological systems can be expected to dwarf pressures generated within our borders.

Canada's third major urban region, Vancouver, could double or perhaps even triple its size in the next thirty years, giving it a year 2000 population of between 1.6 and 2.0 million. It would then contain between 33 and 42 per cent of B.C.'s population. Situated at the mouth of the Fraser River, with a vast resource hinterland to the north, the Lower Vancouver Mainland is in a somewhat different position than Montreal and Toronto respecting environmental spillovers into and from other jurisdictions. But Vancouver is by no means isolated. It shares a common geographical basin with the Seattle-Tacoma-Portland complex. These rapidly expanding cities are expected to increase their population by 2.4 million over the next thirty years, from 3.1 to 5.5 million.[7] This will result in a corresponding increase in pressures on common air, land and water resources, and the life-systems for which they provide a habitat.

High rates of growth are also projected for centres in the Prairies shown in Table 5. Edmonton, Calgary and Winnipeg will increasingly dominate their respective provinces. Although they are not shown on the table, the same is probably true of Regina and Saskatoon. Distance and space protect the principal urban regions on the Prairies from strong externally generated spillovers.[8] A glance at the map reveals, however, that they all depend upon a common water resource, the Saskatchewan-Nelson River system and its tributaries.

The principal cities of the Atlantic Region will also loom large in the population and economic structure of their respective provinces. Domestic pressures on the resources and ecology of the Maritimes will also be reinforced by spillovers from population and economic growth in urban centres of the U.S. Atlantic seaboard.

It is important to note that the pervasive forces of urbanization not only make individual cities grow but they also forge links between cities to create a self-reinforcing urban network that is national and international in scope. Commodity, personnel and information flows between large urban regions make them highly interdependent. Moreover, continued concentration of growth

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[6] *Ibid.* This includes the New York-New Jersey-Connecticut, Delaware Valley, Boston-Brockton and Hartford-Tolland complexes, as well as Washington and Baltimore.

[7] U.S. Dept. of Housing and Urban Development, "Trends and Projections", p. 18.

[8] The environmental costs of developing prairie coal, oil, potash and scenic resources, however, are all linked directly to external demands. The implications of this will be explored in Part Four.

strengthens these linkages and locks each urban region ever more tightly into the national and international urban network. This greater urban network supported by research, educational and governmental institutions, largely determines the efficiency and productivity of the national economy. The economy, in turn, feeds the further development of the major components of the network.

THE PROMISE OF CANADIAN URBAN GROWTH

It is difficult to exaggerate the importance of expanding urban regions to the future quality of Canadian life. The largely man-made urban environment is and will be the prevailing Canadian environment. Its quality will largely determine the quality of life for Canadians.

Canadians will shape this environment; within the next three decades, they will plan and develop more urban area than they have since Maisonneuve founded Montreal in 1642! The required additions to the physical environment in terms of housing, industries, utilities and transportation systems and the continuing remodelling and replacement of the existing stock of homes, streets and commercial buildings as they become obsolete will involve the development of more urban area than now exists. Canadians have the opportunity to mold their urban future to their wishes and in harmony with both the physical and natural components of the urban ecosystem. This is an exciting prospect.

The projections indicate that much higher levels of education could prevail in the future, influencing the tastes of society in new and different ways. They could further expand the growing range of occupations and life styles in our cities, making them more attractive and stimulating as places for living.

This promise of a stimulating life filled with choice could be supported by the economic benefits associated with urban expansion. Economically, the capacity of our cities to generate rising levels of income is well documented. According to 1961 data, urban Canadians enjoy incomes roughly 50 per cent greater than rural residents. Moreover, incomes are 25 per cent higher in metropolitan areas than in smaller centres.[9] The projections suggest that real incomes could rise by well over 100 per cent, providing the basis for individual choice and collective welfare beyond anything conceivable at the moment.

The scenario of Canada's urban future often ends here. But it is incomplete and misleading because it fails to account for the huge burden on man and his environment imposed by unconstrained urban expansion. Although urban growth

[9] E.C.C., *Fourth Annual Review,* pp. 182-83. A Swedish study, F. Kristenssen, "People, Firms, and Regions" published in September 1967 in a publication of the Economic Research Institute of the Stockholm School of Economics, concluded that the size factor alone accounted for a 15 to 20 per cent income difference between Stockholm and the rest of Sweden. The study is cited in Hans Blumenfeld, "Criteria for Judging the Quality of the Urban Environment", *Urban Affairs Annual Review,* III (1968), p. 143.

promises great benefits, its projected pace and polarization will carry huge costs, costs which will reduce and could ultimately eliminate the promised benefits. Possibly the largest component of these costs stems from growing and increasingly unsustainable pressures on the resources of the urban environment and on the life systems which they support, including man. Before we can complete the scenario, then, we must look at the possible future dimensions of some of these pressures.[10]

[10]The preceding six paragraphs are based, in part, upon and are supported largely by the analysis and data in N.H. Lithwick, *Urban Canada: Problems and Prospects.*

Chapter IX

The Urban Environmental Management Problem

In discussing urban environmental management problems one should begin by distinguishing between the rate at which urban regions grow and the effects of growth *within* urban regions. It is evident from the earlier discussion that the rate of growth of such regions is determined largely by external forces which the urban regions themselves do not and cannot control. These forces include capital formation, income levels, industrial development, technological change and national and international movements of people, goods and information. Urban governments have little control over these forces and hence over the rate of growth of their regions. For the most part, they can do little more than respond to the demands imposed by growth.

Urban governments, however, have a fundamental role to play in responding to the demands of growth. Many strategies that determine the quality of the urban environment can be best applied at the level of the urban region. Even given the powers and resources necessary to apply these strategies, it is apparent that the urban region and its government(s) cannot alone satisfy the demands imposed by such growth. Many demands upon the urban environment, from clean air to quiet streets, are influenced by external forces and are subject to powers exercised by senior governments. Frequently, therefore, environmental management strategies applied by urban governments cannot be effective without the concerted application of related strategies by the provincial and federal governments. Urban environmental management presents all orders and levels of government in Canada with a significant set of interrelated demands.

THE RESOURCES OF THE URBAN ENVIRONMENT

Within the context of environmental management, it is useful to view the urban region as an ecological system that is a dynamic and open-ended component of the global ecological system. It spills over into and receives spillovers from other related ecosystems – a river basin or lake, an agricultural hinterland, or an

atmospheric trough shared with other urban regions. It is linked solidly with other jurisdictions, urban, provincial, national and foreign. It is composed of both natural and man-made elements, animate and inanimate, joined together in a constantly changing web of almost infinite complexity. Indeed, within the urban ecosystem as elsewhere, it is the impact of the man-made upon the natural elements that gives rise to problems of environmental management. This, coupled with the complexity of the system, makes it essential to group both the natural and the man-made elements into a limited number of meaningful categories.

This is greatly facilitated if we view the natural elements of the system as "urban resources" supporting a variety of interrelated life systems, including man. This involves an extension of the traditional concept of "natural" resources. It involves, for example, recognizing the essential productivity of resources such as space, topography and climate and the social utility of what have been called amenity resources such as attractive and quiet surroundings. Taken together, these may be referred to as "environmental resources" or, within the context of the urban region, "urban resources". Collectively they form an important part of the base that supports urban society.

There are nonetheless essential differences between these resources, the most important of which is the degree to which they are or could be subjected to property rights and allocated by market forces. This varies, even for different uses of a specific resource. Water for drinking or industrial cooling, for example, is normally metered and managed as a private good while for recreation and navigation it is normally managed as a public good. Surface land is generally allocated by the market but this is becoming increasingly modified by public regulation. These differences are not critical. The literature on environmental management in the field of water resources, for example, has long faced the problem of relating mobile and static resources and public and private goods.

In the discussion that follows, urban resources will be considered under five categories: space, audio, visual, air and water. While space has three dimensions, surface space, or land, is clearly the most important and is the focus of the discussion.[11] The sources and effects of air pollution are concentrated in urban regions, but because of the particular mobility of the air resource and its inevitable spillovers between urban and non-urban environments and among different jurisdictions, detailed discussion of it is reserved for Part Five.

Viewing the natural elements of the urban ecosystem as resources provides us with a framework for discussion that is both comprehensive and manageable. It

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[11] For a systematic treatment of this general concept, see *The Quality of the Urban Environment*, H.S. Perloff, ed. (Baltimore, Johns Hopkins Press for Resources for the Future, Inc., 1969). It should be observed that in Table I, pp. 22-23, Perloff identifies 30 elements that constitute the urban environment and "provide a framework for evaluating policy measures . . ." The above resource categories, however, comprehend all of these elements – which are more detailed than required for consideration of the constitutional aspects.

lends itself to the application of the spillover and other criteria mentioned in Part One and it is constitutionally more familiar. It also reduces the dimensions of the problem so that one is not forced into the impossible position of having to exhaustively examine every conceivable environmental problem. Instead, discussion can be limited to those activities that represent the most significant sources of pressure on urban resources. The discussion will in fact focus on four categories of activity: transportation, housing, industrial growth and outdoor recreation. It will examine the tendency of these activities to press on the five urban resources mentioned above until their assimilative capacity is threatened or exceeded. The implications of the resulting environmental deterioration for the role of government will be considered in Chapter XI.

THE SHAPE OF THE URBAN REGION

The critical element in any city economy is the need for certain activities to be concentrated. Production facilities, labour supplies and markets must be closely related to each other in order to reduce transportation costs and capture the other benefits of concentration. The main problem of the city economy, however, is that space is limited and various users have to compete for this scarcest of all urban resources. The result has always been a compromise between how much land is taken for a given purpose, what kind of transportation costs it can bear and, consequently, where it is located. The internal structure of the city, its functional relationships and their component parts, reflect the compromises that have been made over the years.[12]

The principal factor in this compromise, and hence a major determinant of the internal structure, density and area of the city, is the modes of transport employed within it. It was the development of new techniques of short-distance, intra-urban transportation that finally broke the narrow confines of the tightly packed nineteenth century city. Electric traction came first, but the most powerful instrument has been the motor vehicle. It has increased by 25 times the amount of surface space accessible for development within a given time distance.[13]

The automobile has in fact given rise to an entirely new form of human settlement which will be referred to simply as the large urban region. It has not, however, altered the need for certain activities to be concentrated near the centre of the region. The general form of the large urban region reflects this. Various

[12] For a full treatment of this see N.H. Lithwick, *Urban Canada: Problems and Prospects.*

[13] Hans Blumenfeld, "Environmental Aspects of Transport and Urban Development", (unpublished, 1969), p. 15:

> While pedestrian movement covers only 3 miles in an hour, the private automobile – which accounts for over 70% of all person-miles in the Montreal and Toronto regions . . . covers, even with traffic congestion, at least 15 miles per hour. In fact, the radius of urban development for cities of the same size has expanded at least five times in the past 120 years. As this has made 25 times as much urban land accessible within a given time, the range of choice within a given time distance must have been increased at least fivefold.

components can be distinguished, the core, the mid-ring and the suburbs. Although these components are invariably irregular, they may be defined crudely by their distance from a central point.[14] In any specific urban region the vague boundaries between these areas are conditioned by geography and history and are in a constant state of change. It should also be noted that some authors, concerned with the total urban environment, add a fourth component beyond the suburbs proper and call it the "Metropolitan Orbit"[15] or the "Rurban Fringe".[16]

This picture is greatly simplified, but it provides a framework for the discussion that follows. It also illustrates the principal economic force at work in shaping the structure of urban regions: the allocation of scarce land for different purposes within the limits imposed by transportation.

ENVIRONMENTAL EFFECTS OF URBAN TRANSPORTATION

It is easier to discuss the environmental aspects of urban transportation and their relationship to the role of governments if one differentiates between the terminals and corridors of long-distance transport on the one hand and the streets, access roads and subways of the urban regional transportation system on the other. It is also useful to differentiate between the basic modes of transport, that is road, rail, pipelines, water and air.

The enormous effect of all forms and modes of transport on the environment of urban regions, is clearly high-lighted by the motor vehicle. Its impact has been both positive and negative. It was and is the principal instrument in the expansion of our cities and much of the economic advantage of urbanization can be attributed directly to it. The mobility of the vehicle has also made it possible for more urbanites to enjoy what they perceive to be the advantages of a single family dwelling in suburbia, with its additional space, air, light, sunshine and greenery. For many it is the least expensive form of urban transport, given the present pricing system and service alternatives, and it provides superior comfort and great flexibility.

While the benefits of the motor vehicle are substantial, they are being bought at huge costs to man and his environment. Whether in the form of an automobile, truck or bus, the motor vehicle presses on all of the urban resources – land, audio, visual, air, and water – and on some of them more severely than on others. The effects of the more significant pressures are contained largely within the urban regions. This is true of the effects of the motor vehicle on audio and visual resources. Its impact on space is greatest within the urban region but it is also felt in

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[14] *Ibid.*, p. 5. Blumenfeld notes that land absorption per 1000 of urban population increases or, expressed inversely, density decreases and *decreases regularly* from the centre to the periphery.

[15] *Ibid.*, p. 6.

[16] Alice Coleman, *The Planning Challenge of the Ottawa Area* (Geographical Paper No. 42) (Ottawa, Queen's Printer, 1969), p. 11.

surrounding areas since it enables population and industry to spill over established urban boundaries into adjacent agricultural and recreational land. Its impact on water resources, either directly or indirectly via spillovers onto the land and into the air, generate costs that are borne in part by the urban region but are mainly passed on to other jurisdictions downstream. Its emissions into the air resource are felt initially and most severely within the urban region but also spill over into and impose great costs on other jurisdictions.

The economic, social, health and other costs of environmental spillovers from the motor vehicle can be expected to increase substantially over the next three decades. As indicated by Table 6, car ownership is projected to more than double between 1970 and 2000, unless it is restrained, rising from 7.0 million vehicles to nearly 15.0 million. Car mileage, which at present accounts for about 70 per cent of total mileage could show an even greater increase. Commercial mileage can be expected to triple and perhaps even quadruple during the forecast period. Up to one-third of this increase could occur in our major urban regions.

The trends shown in Table 6 will be reflected in a large increase in requirements for urban roads. These requirements will be greater and their costs much higher in our large urban regions. The environmental costs of urban roads and their uses could easily dwarf the direct financial outlays required for construction, operation and maintenance. We will look briefly at the possible dimensions of *some* of these environmental costs – to the extent that they can be inferred from the trends – in terms of space requirements, congestion, and audio, visual and air pollution.

Table 6

Projections of Motor Vehicle Ownership and Mileage in Canada: 1968 to 2001

	Private Automobiles[a] (millions)		Commercial Vehicles[b] Freight Ton-Miles (billions)	
Year	Low	High	Low	High
1968	6.16	6.16	21.2	21.2
1971	6.64	6.69	23.3	23.7
1981	8.92	9.11	32.7	36.2
1991	11.37	11.78	45.0	55.4
2001	13.64	14.31	60.9	84.4

[a]Figures are taken from Systems Research Group, *Canada: Transportation Projections to the Year 2000* (Toronto, 1970). These figures assume the medium population projections. The 1968 figure is taken from D.B.S., *The Motor Vehicle 1967: Part III, Registrations* (Cat. 53-219). The low estimates assume a saturation level of 0.45 cars per capita rising from 0.30 in 1968 to 0.31 in 1971, 0.35 in 1981, 0.38 in 1991 and 0.40 in 2001. The high estimates assume a saturation level of 0.50 cars per capita, rising from 0.30 in 1968 to 0.33 in 1971, 0.40 in 1981, 0.44 in 1991 and 0.47 in 2001.

[b]*Ibid.*

The automobile has been called a land eater and this is true even though the amount of pavement required for *moving* cars is surprisingly small. Less than three per cent of the surface area of a major metropolitan region could accommodate the *movement* of traffic during the peak half-hour. Even in Los Angeles, freeways occupy only two per cent of the city area. A far greater amount of land is required for *standing* cars. By the year 2000, the Montreal and Toronto regions could each require up to 2.25 million spaces for parking cars alone. This translates into nearly 70 square miles. If one adds a further 22 square miles for major roads and freeways, the total exceeds 13 per cent of the projected requirement of 700 square miles for all land uses in each of the two urban regions.[17] The direct financial outlays required for land acquisition and construction of these expressways and parking facilities will be huge, but they do not begin to reflect the total costs involved. In the downtown core, for example, the unplanned razing of older buildings for temporary parking lots is often a source of concentrated visual, noise and air pollution, congestion and traffic hazard. In the core and mid-ring, expressways and parking facilities can devour low-rental housing,[18] historic buildings and parks, and they can destroy the quality of entire neighborhoods as desirable places in which to live and work. In the suburbs and outer orbit, major roads tend to be cut through river valleys and other areas where land values are relatively low but recreation potential may be high. The extensive surfacing of all of the roads and related facilities required for motor vehicles adds greatly to storm water run-off, thereby increasing flood flows. Unfortunately, because many of the above-mentioned costs cannot be quantified, they have been dismissed or ignored. But they are nonetheless real.

Passenger cars account for 80 per cent of all vehicles on urban streets and over 90 per cent at peak hours. Because road traffic inevitably exhausts and exceeds the capacity of freeways built to accommodate it, the result is congestion. This congestion slows down the movement of all forms of road traffic, not only the private vehicles themselves, but also commercial transport and surface transit. At typical speeds of 15 mph, the marginal congestion costs imposed by one vehicle on another are of the order of 10 cents per mile. At 10 mph they increase to 25 cents per mile.[19] This translates into overall costs amounting to hundreds of millions

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[17] Blumenfeld, "Environmental Aspects of Transport and Urban Development", pp. 17-18: By the end of the century, Canadians probably will be close to owning one car for every two persons. Each car requires one parking space at the home base; about three-quarters will need one at the place of work; and a total of 0.75 spaces per car is a conservative estimate for parking required for shopping, business, schools, recreation, visiting, etc. Thus each car requires 2.5 spaces, each averaging, with the space required to move in and out, at least 340 square feet, for a total of 850 square feet.

[18] This is in accord with the views of Alan Armstrong, Executive Officer, Canadian Council of Urban and Regional Research, as expressed in a private communication to the author.

[19] J. C. Tanner, "Pricing the Use of the Roads – a Mathematical and Numerical Study" in *Proceedings of the Second International Symposium on the Theory of Road Traffic Flow* (Paris, Organization for Economic Co-operation and Development, 1965), pp. 317-337.

annually in time alone.[20] But that is only the beginning. Congestion reduces the attractiveness of public transit, reducing patronage and making it more difficult to maintain service. It results in seemingly irresistible pressure on public bodies to construct more freeways, in spite of their attendant costs and the inevitability of their capacity being exhausted. And, at peak hours, it results in intense visual, noise and air pollution.

It is evident that the trends for passenger and commercial mileage in Table 6 portend even higher levels of noise and air pollution in our cities. This could, of course, be reduced or eliminated altogether by the modification or replacement of the internal combustion engine as the source of power. Although such a breakthrough would be welcome, it should be noted that it would not affect those environmental costs that derive from pressure on urban land resources. The motor vehicle's appetite for land and its propensity for congestion clearly do not stem from its power plant.

Enough has been said to illustrate and emphasize the crucial impact of the motor vehicle and road network on the quality of the urban environment. Less pervasive but perhaps no less significant is the impact of the terminals and channels for long-distance transport. These include harbours and harbour facilities; railway stations and access lines; air terminals, flight paths and access roads; and bus stations, road freight terminals and certain major expressways. Historically, harbour and railway terminals have been major determinants of the location, function and growth of cities. Cities grew up because they were located at a major terminal. Today the reverse is often true, terminals are expanded or new ones established because they serve a big city. Many of their most significant environmental spillovers are wholly contained within the urban region. They withdraw large areas from development and other urban uses. They interrupt the urban road grid and generate internal traffic.[21] They are significant sources of visual, noise, air and water pollution.

The impact of harbours on the urban waterfront illustrates this fact. Five of the nine larger urban regions owe their origin to harbours and their cores are located near the waterfront. As both city and harbour grew, their mutual needs for additional land came into conflict. As land prices in the core rose, waterfronts fell into disuse, became blighted, affected by water pollution and cut off from pedestrian access by buildings, highways and railroads. Yet, waterfronts offer excellent opportunities for the creation of urban beauty, outdoor recreation facilities, well-planned public and commercial institutions and certain forms of housing. As these opportunities are recognized, counterpressures emerge resulting in

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[20] Blumenfeld, "Environmental Aspects of Transport and Urban Development."

[21] Blumenfeld, "Environmental Aspects of Transport and Urban Development", p. 36. Terminals are the most important single points of origin and destination for the *intra-urban* movement of both goods and people. Hence they are both a large and an integral part of the urban transportation system.

the replanning and redevelopment of waterfront areas. The redevelopment of part of Montreal Harbour for Expo '67 and the development of Ontario Place in Toronto illustrate the potential of this valuable space resource.

A similar process has occurred with rail transport and is now beginning with air transport. Their terminals were built close to the core of the city (or vice versa) for economic reasons. The negative environmental effects grew as the city developed and the use of the terminal increased. Such effects are frequently perceived decades before any successful attempts to resolve the conflict.[22] The difficulties encountered in the complex situation around Vancouver harbour where a number of railways are involved illustrate this problem as well as those referred to in the preceding paragraph.

The pressure of transportation terminals and corridors on urban resources can be expected to increase significantly over the next three decades. The projections in Figure 7 suggest that inter-urban passenger travel by road could double during this period while travel by rail and bus could triple and travel by air could jump 15 times. Similarly, the figures in Table 7 suggest that freight carried by road transport could triple, while that carried by rail and water quadrupled, and that carried by air again increased 15 times. Virtually all of this colossal increase in passenger and freight traffic will have its origin or destination or both in urban regions, most of it in our nine largest urban regions. This will result in a need for almost continuous expansion of terminals and corridors for all modes of transport. As in the case of urban streets and access roads, the direct and indirect environmental costs of this expansion could impose a great burden on Canadians living in urban regions.

Table 7[a]

Projected Total Freight-Ton Miles by Various Modes of Transport for Canada: 1971-2001 (billions)

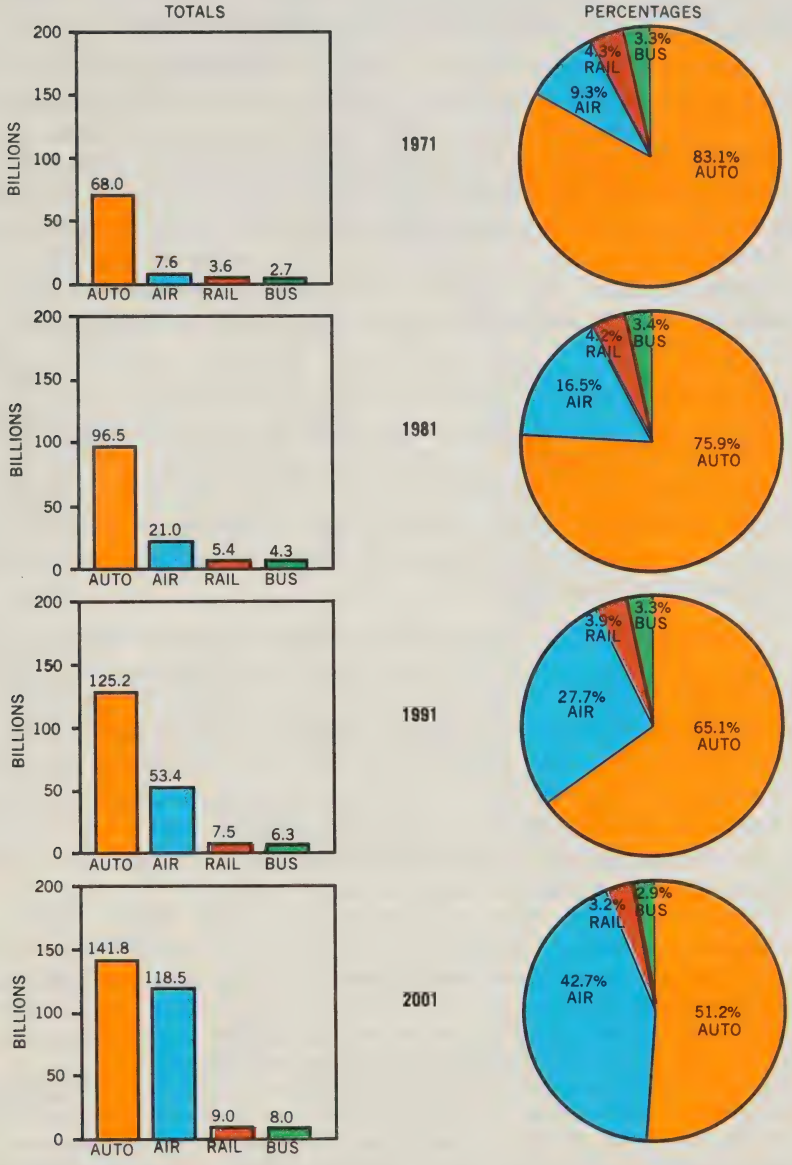
	Road		Rail		Water		Pipeline		Air	
	Low	High	Low	High	Low	High	Low	High	Low	High
1971	23.3	23.7	97.4	105.7	73.4	74.8	78.7	84.0	.13	.13
1981	32.8	36.3	118.7	120.7	114.0	126.2	153.2	186.0	.29	.32
1991	45.0	55.4	141.4	286.6	172.9	213.0	274.8	368.3	.64	.79
2001	60.9	84.4	165.8	484.8	258.3	358.3	476.7	681.1	1.42	1.96

[a]Systems Research Group, *Canada: Transportation Projections to the Year 2000* (Toronto, 1970).

[22]*Ibid.*

FIGURE 7

PROJECTED INTER-URBAN PASSENGER MILES BY MODE FOR CANADA: 1971-2001 (BILLIONS)



Taken from Systems Research Group, Canada: Transportation Projections to the Year 2000 (Toronto, 1970).

ENVIRONMENTAL EFFECTS OF URBAN HOUSING

Canadians spend most of their time in the environment of their residential neighborhood. Wives, retired parents and school-age young people only occasionally leave the area. The impressionable childhood years are spent there. Even working people spend a greater amount of time at home than on their jobs.

This important environmental experience is enriched by attractive, well-ordered surroundings; it is diminished by disorder and ugliness. The neighborhood may be in the congested downtown core, gradually succumbing to visual, noise and air pollution and to litter and parking lots. It may be located in the mid-range, struggling to maintain its structure, character and dignity in the face of increasing spillovers from the core and pressures for direct access freeways from the suburbs. Or the neighborhood may be mass-produced, with a surface bulldozed free of trees and other "obstacles" and replanted with utility poles, billboards and other "necessities". Deterioration can be found in both old and new neighborhoods.

The next three decades will provide Canadians with an unparalleled opportunity to improve the quality of their neighborhoods. Projections indicate that by the year 2000, Canadians will require an additional housing stock of between 7.2 and 10.1 million units. This is an increase of from 133 to 187 per cent over the 5.4 million units available in 1966.[23] Coupled with all other related land uses, this could require that an additional 3000 to 4000 square miles of serviced land be *added* to Canada's urban regions. In 1966, these regions contained roughly 2500 square miles of serviced land.[24]

As indicated by Table 8, most of these projected housing units and serviced land will be required in or near the nine largest urban regions. The projections suggested that the three largest regions will require between 2.6 and 3.3 million units, nearly one-quarter of the national total. They will also have to more than double, perhaps triple, the amount of serviced land. The Toronto region alone could require an additional 400 to 650 square miles, Montreal a similar amount, and Vancouver could require 125 to 250 square miles.[25] Land will be needed not only for housing but also for the whole spectrum of related uses – schools, hospitals, shopping centres, parks and community centres.

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[23] Systems Research Group, *Canada: Family Household and Housing Projections to the Year 2000* (Toronto, 1970).

[24] These figures are crude estimates based on past high densities of 6000 persons per square mile. Over half the land area of our cities is devoted to residential use.

[25] These large land requirements appear more credible when one notes that a higher proportion of the required units could be for family households than has been the case in recent years. Over the next decade, the post-war baby boom should lead to a major increase in family households. Family households typically wish single family dwellings and these are very space-intensive. In the future, residential and land requirements in our major urban regions could be extremely heavy, unless changed attitudes facilitate the development of radical new forms of family housing along with strong incentives and controls favouring their use.

There is little that the urban region can do to influence the macro-economic, social, cultural and other forces underlying these demands. The forces leading to immigration and internal migration, for example, are largely external to the urban region. The provision of housing and related services, however, will further increase the pressure on all urban resources. These pressures will lead to increased costs for these resources – costs of supplying them in quantity and the costs of enhancing and/or maintaining them in quality.

Table 8

Additional Housing and Space Requirements:
Nine Major Urban Regions: 1961 – 2001[a]
Housing (000's units)

Urban Region	1961-71	1971-2001 Medium	1971-2001 High
Toronto	231.4	1099.8	1235.0
Montreal	265.4	1157.6	1340.0
Vancouver	93.2	393.6	460.0
Sub-Total	590.0	2651.0	3035.0
Ottawa-Hull	49.3	218.6	276.0
Edmonton	45.7	222.2	238.0
Hamilton	40.2	169.3	189.0
Quebec City	38.9	177.7	179.0
Calgary	35.2	174.0	258.0
Winnipeg	32.6	104.4	142.0
Total	831.9	3717.2	4317.0

[a]Compiled by Central Mortgage and Housing Corporation from data provided by Systems Research Group.

ENVIRONMENTAL EFFECTS OF URBAN INDUSTRIAL PRODUCTION

This is equally true of the demands on urban resources generated by industrial development. Projections of Canadian production by industry are displayed in Figure 8, while Table 9 shows the year in which the 1967 level of production could double, triple or quadruple. In constant dollars, these projections represent rough indices of absolute growth in total output. They also represent rough indices of the *potential* increase in this source of deterioration of urban resources.[26]

[26] As indicators of the latter, one would prefer to have direct forecasts of the amounts of solid, liquid, gaseous and other wastes that would be generated by this production in the absence of effective countermeasures. Some estimates of specific pollutants will be presented later, but no overall projections are available.

Table 9[a]

Projected Year 1967 Output Doubled, Tripled and Quadrupled by Industry: 1967-2000

	Year Industry Output		
	Doubled	Tripled	Quadrupled
Utilities	1976	1981	1985
Manufacturing	1979	1986	1991
Transportation	1980	1988	1993
Construction	1984	1994	2000
Mining	1979	1985	1990
Agriculture	1996	–	–
Forestry	1984	1995	–

[a]Systems Research Group, *Canada: Economic Projections to the Year 2000* (Toronto, 1970).

These projections show very high growth rates in the pollution-intensive industries that are likely to concentrate in and around our major urban regions. On the basis of the medium projections, manufacturing output could double by 1979, triple by 1986 and increase fivefold by the year 2000. The output of goods-producing industries follows a parallel trend with a one- to two-year time lag. Taking the lowest projections, construction would double by 1984, triple by 1994 and quadruple around 2000. Electrical and other utilities are located mainly in and around urban regions. With the shift from hydro to thermal production, both conventional and nuclear generating stations are locating in or close to the load centres. The utilities industry, growing at 8.1 per cent, would double its 1967 output by 1976, quadruple by 1985 and by the year 2000 it would have increased its output by a factor of 12!

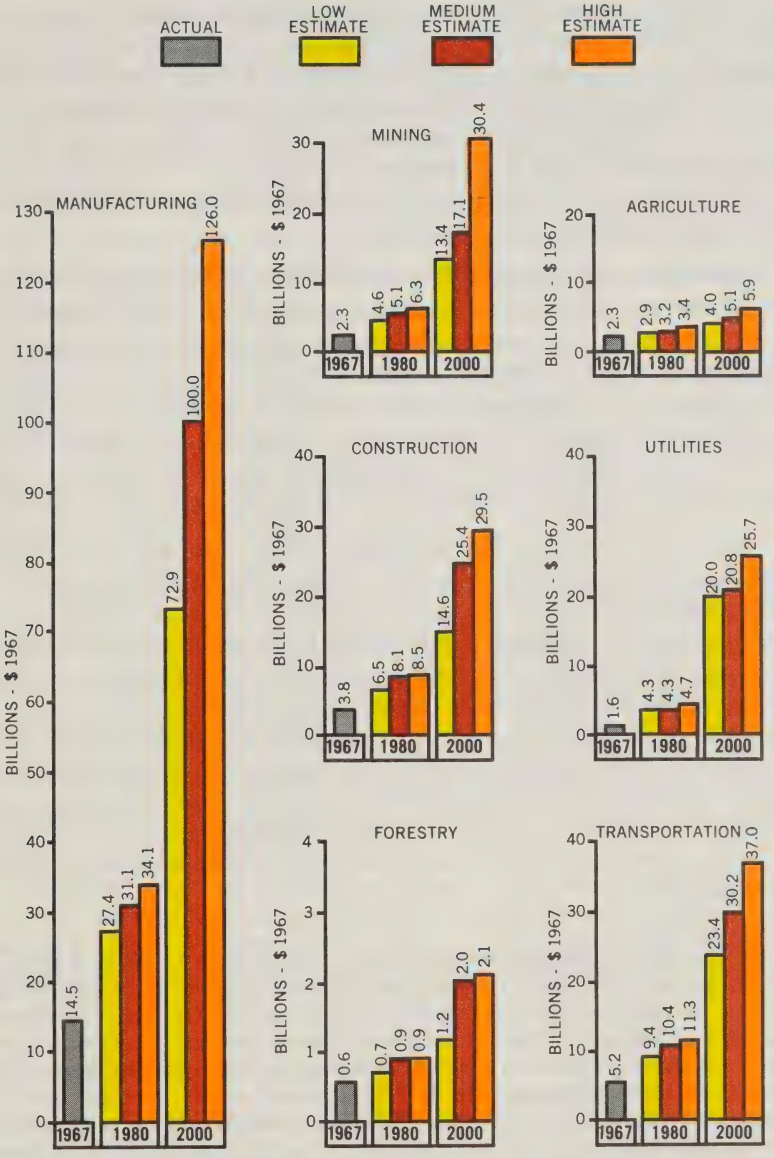
Industrial activity would also generate substantial demands for urban space, reinforcing the pressures stemming from housing and transportation. It would require an enormous increase in the consumption of fuel and raw materials of various kinds and in the use of water for industrial cooling and processing. This would result in a corresponding increase in emissions of noise and gaseous, liquid and solid wastes. *In the absence of effective counter-strategies,* it is a practical certainty that these emissions would tend to reach and exceed the assimilative capacity of the urban ecosystem.

RECREATION

Leisure time activities and outdoor recreation are normally viewed only as desirable uses of urban resources. Within the context of this study, however, we are concerned with leisure and outdoor recreation mainly as a competitor for urban resources and another growing source of pressure on them.

FIGURE 8

PROJECTED PRODUCTION BY SELECTED INDUSTRIES: 1967-2000



Taken from Systems Research Group, Canada: Economic Projections to the Year 2000 (Toronto, 1970).

Compared with transportation, housing and industrial production, the future demand for leisure and outdoor recreation in the urban region is vague and shapeless and difficult to quantify. Leisure time comprises those periods when a person can choose what he wants to do. The range of pursuits is infinite, from reading in a park or attending a football game to gardening or scuba diving. The need for leisure time activity is not disputed though its sources may not be clear. Current research supports what common sense has long observed, that the "overload" on man's system from the stresses of a highly interactive urban life, does affect his behaviour.[27] The pressures on the city dweller are obviously increased by environmental factors such as congestion, noise and air pollution.[28] "Sensory overload" is an enormous and growing contributor to the demand for outdoor recreation, a demand now symbolized by the weekend traffic jams of people trying to leave our major urban areas.

The demand for leisure and recreation activities thus has many facets. Some pursuits best suit daily periods, weekends or annual vacations. Children, working people, housewives, the unemployed, students and the retired all make different recreational demands on the environment. Most of this recreation is obtained in the urban region; some is obtained in resource-based or wilderness areas; and some in the intermediate countryside between. As the Canadian population concentrates into fewer larger centres, each of these environments will be subject to increasing demands, but the urban environment itself will experience the heaviest demands.

This is supported by the population, leisure time and other trends cited earlier. It is also supported by 1966 figures which show that 89 per cent of the total leisure time budget was spent in the community of residence and only 11 per cent on trips outside.[29] Although higher incomes will mean greater mobility and a greater tendency to seek recreation beyond the city, technology is unlikely to produce, in the foreseeable future, a system that will enable the majority of city dwellers to leave the city for daily and weekend recreation. Similarly, although education and communications media will compete for leisure time they are as likely to stimulate and reinforce outdoor recreation demand as to substitute for it.[30] People are likely increasingly to regard the urban region as the centre of their life and to expect it to provide both a satisfying environment and full opportunity for recreation.

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[27] S. Milgram, "The Experience of Living in Cities", *Science* (March 13, 1970), p. 1462.

[28] In this context see Elinor C. Guggenheimer, *Planning for Parks and Recreation Needs in Urban Areas* (New York, Twayne, 1969), p. 26, and also Julian W. Smith, "Development in the Field of Education Affecting Outdoor Recreation Purposes", in *Trends in American Living and Outdoor Recreation* (Outdoor Recreation Resources Review Commission Report No. 22) (Washington, 1962), p. 134.

[29] Information provided by W. M. Baker, Park and Recreation Planner, 62 Sloley Road, Scarborough, Ont.

[30] Paul Lazarsfeld and Max Kaplan, "The Mass Media and Man's Orientation to Nature", in *Trends in American Living and Outdoor Recreation* (Outdoor Recreation Resources Review Commission Report No. 22) (Washington, 1962), p. 190.

Urban outdoor recreation is a great consumer of space. It has been estimated that municipal parks alone occupied 125,000 acres in Canadian cities, towns and villages in 1966.[31] The 13 largest cities may have accounted for 20,000 acres or 20 per cent of this total, for a per capita average of 2.3 acres per 1,000 population. In the United States, the National Recreation Association has proposed as a general guide a standard of 10 acres of park and open space per 1,000 population within the city, with an equal area in parkways, larger parks, forests, etc. either within or adjacent to the city.[32] Even a ratio of six acres per 1,000 would require 191,000 acres of municipal parkland in Canada by the year 2000, an increase of 50 per cent. In the 13 largest cities, however, this ratio would require that the present 20,000 acres of parkland be multiplied 5.6 times to 112,400 acres. Substantial land acquisition seems inevitable, therefore, if supply is to keep up with growing demand.[33] This need for land for parks is certain to conflict with existing or potential land uses, be they housing or industrial development, transportation corridors or harbour terminals.

Outdoor recreation will also have considerable impact on the water resources of the urban area as more people seek to make use of the recreational opportunities they offer. The number and variety of watercraft will increase and contribute to the water pollution by engine exhausts, spillage of oil and gas, human wastes and garbage. Ironically, the more agreeable the surrounding shoreline and the water quality, the heavier and more diverse the potential recreation uses, and the greater the potential congestion on both land and water.

Recreation in the urban context both contributes to and detracts from the quality of visual images. Open spaces and parks enrich a city's visual image, but outdoor recreation in the urban region leads to intensive use of the limited green areas and, inevitably, the pressure of human occupation results in the elimination of some floral species and the disappearance of more birds and animals. Recreation demand is, along with other land uses, a major threat to the visual resource of the enclaves of natural wooded areas in urban regions. Discretionary time activities are almost synonymous with picnics and pop bottles and are a major source of litter in the form of waste paper, cans, bottles and other garbage.

The direct impact of outdoor recreation on the urban environment can be seen, felt, heard and smelled, but the reverse connection is no less important. Recreation is directly affected by the quality of urban resources. If present trends of through-way construction, suburban sprawl, larger individual lots, industrial land

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[31] Information provided by W. M. Baker.

[32] M. Clawson and L.L. Knetsch, *Economics of Outdoor Recreation* (Baltimore, Johns Hopkins Press for Resources for the Future, Inc., 1966), p. 14. It is recognized that the scale of recreation facilities is greatly influenced by topography, climate and other factors such as the availability of space, or its lack. The standard of the National Recreation Association was intended as a general guide and it is useful as such.

[33] Information provided by W. M. Baker.

use, etc., are perpetuated, then green space and recreational land supply per capita from core to urban fringe will be steadily reduced. Recreational pressure on the remaining space could increase to the point where flora and fauna disappear. If the other users pollute natural water bodies until they are unsafe or too unpleasant for recreational activities, pressures on the remaining water resources will increase. If noise and visual pollution grow, the demand to escape the urban region will be intensified. Yet, the vast majority of people would have no alternative but to continue to spend their discretionary hours in the urban environment with decreasing enjoyment.

Chapter X

The Management of the Urban Environment

Within the next three decades, on the basis of the projections, Canadians will likely have to create more urban residences, more commercial and industrial facilities, more hospitals, more parks and recreation areas, more transportation facilities and more power and other utilities than have been constructed in the entire history of our nation. The way in which this gargantuan task is accomplished will decisively determine the quality of the Canadian environment for the coming century.

The pressures that this development places on urban resources will tend to exceed their assimilative capacity. Experience elsewhere warns us that the resulting deterioration could mount so rapidly and the economic, social, cultural, physiological and psychological side effects could be so pervasive, that our urban regions could be destroyed as safe, healthy and attractive places in which to live, work and play. To avoid this deterioration, the development of our urban regions must proceed in harmony with the natural constraints imposed by the interdependent human, biological and physical components of the urban ecosystem.

In this chapter, five major categories of environmental deterioration are examined. No attempt is made to catalogue all sources of deterioration under each category nor to identify all of the possible side effects. That would be an impossible – and pointless – task. Instead, the nature of each category is considered, along with its possible dimensions and some of its more prominent side effects. At the same time, some of the characteristics relevant to the roles and responsibilities of government will be drawn out.

URBAN SPACE CONGESTION, BLIGHT AND SPRAWL

Congestion, blight and sprawl are interlocking phenomena that stem from pressures on space resources. They both reflect and give rise to pressures on most other urban resources. The growing demand for urban goods and services – transportation, housing, industrial facilities and utilities – results in huge demands for space. Land prices rise inducing population to seek space more remote from the core, as distance is traded off against more, and less expensive land. This economic push outwards is supported by transportation mobility and reinforced by urban

man's still deep desire to seek closer proximity to nature and to enjoy cleaner air, better water, finer schools, more congenial neighbors – hopefully all at lower rates of taxation. The result is suburbanization. The result is also peak-hour congestion of transit, with associated stress and air pollution, as more and more people force their vehicles into fixed transportation systems. Public pressure then grows for more and faster systems; new systems are installed; more distant land becomes accessible; more population moves further out; transit congestion recurs with heightened noise, visual and air pollution in the core.

Each time the process repeats itself, the side effects become more intensive and pervasive. The demands on the transportation system are greatest in the core, both for rights-of-way and for storage or parking. Yet it is here that land prices are highest, streets are narrowest and alternative uses with large fixed investments already exist. This multiplies the cost of any transportation improvements and increases the difficulty of providing them. The internal structure of the urban region is determined largely by this process. Deterioration in the form of congestion and blight and sprawl also flow inevitably from it.

Sprawl is the rapid, uncoordinated extension of suburbs at the fringes of the urban region. It carries costs that are both high and widely diffused. Random development consumes unique space resources, irreplaceable agricultural land or choice valleys, watersheds and wildlife habitat needed to satisfy the growing recreational needs of the urban region. Access roads linking scattered dormitory villages encourage ribbon commercial development and display vistas of billboards and all-night eateries. Pockets of urban development, unable or unwilling to support proper sewer and water facilities, release raw sewage directly into waterways or employ septic tanks which often result in pollution of groundwater aquifers. If and when they are tied into a central system, the central facilities become over-stretched and over-burdened. Each extension of these facilities entails a "sprawl tax" to cover costs that could have been reduced by rational planning.

The push to the suburbs is spearheaded and sustained by upper and middle income families. Low-income families do not have much choice. Unable to afford a single car, much less the second car often necessary for suburban living, and without the option of low-cost public transit serving outlying suburbs, they compensate for high-cost core land by overcrowding. This in turn leads to the deterioration of housing stock, and blight is added to core congestion, air and noise pollution. The blight is contagious; it spreads rapidly outward from the core, marked by shabby buildings, barren parking lots, cluttered streets, jumbled signs, noise, fumes and litter. Downtown loses its appeal not only to residents but to visitors, shoppers and employees.[34]

[34]This description of the process of congestion, blight and sprawl is supported, in part, by the analysis in N.H. Lithwick, *Urban Canada: Problems and Prospects* and, in part, by the analysis in private communications from H.P. Oberlander, Director, School of Community and Regional Planning, University of British Columbia, Vancouver, and A. Armstrong, Executive Officer Canadian Council on Urban and Regional Research, 151 Slater St., Ottawa, Canada.

With a process so diffused and interrelated, it is not possible to place a meaningful measure on its current or future dimensions. In the absence of effective counter-measures, however, the urbanization trends outlined above will tend to accelerate and exacerbate this process, especially in the larger urban regions.

The phenomena of congestion, blight and sprawl exhibit several characteristics relevant to the role of governments, including high external costs. These costs are pervasive and difficult to measure, including economic, social, physiological, psychological, even cultural costs. Two examples will illustrate their nature and breadth.

Experience elsewhere has shown that congestion coupled with poverty and with air, noise and visual pollution, can contribute to, if not lead to, a climate of hostility and violence in the central city. Biological research has revealed drastic behavioural changes in animals under crowded environmental conditions. Anthropologists have recently emphasized the parallel with the behaviour of urban man under comparably crowded conditions.[35] Crowding affects human behaviour and leads to conditions of stress. Many scholars, including Dr. Hans Selye, accept a certain degree of stress as normal and even useful, but emphasize that too much stress often means distress, leading to physical or social sickness and ultimately to violent behaviour. This can impose high costs on society.

Congestion and blight also threaten sites of historical and cultural value. The history of Canada is reflected in the older buildings and neighborhoods located in or near the downtown core of our cities. These old buildings and neighborhoods, in addition to their functional and social importance to the people who use and live in them, often comprise irreplaceable and outstanding symbols of our nation's history and heritage. Some may be of national significance, others provincial, others local. Some sites and buildings of historical and cultural value have been saved, but more have been lost. With higher education levels, rising incomes and greater leisure time, the importance of these areas could increase in future years enriching the lives of residents and non-residents alike. Yet many sites are threatened by the encroachment of blight and well-intentioned "raze and rebuild" renewal programs designed to eradicate it.

These two types of spillover costs highlight two other characteristics relevant to the role of governments. One is that most of the negative spillovers of congestion, blight and sprawl are experienced largely within the urban region. The other is that the spillovers, like the process itself, are *physically interdependent.* These two characteristics indicate that the urban region is the appropriate level at which to apply the management functions concerned with regulating the physical components of the urban system. These functions include comprehensive planning of the urban region and the entire range of regulatory controls, taxation

[35] See Robert Ardrey, *The Territorial Imperative* (New York, Atheneum, 1966), and Edward T. Hall, *Hidden Dimension* (New York, Doubleday, 1966).

instruments and fiscal incentives required to secure the implementation of plans. They also include the information systems and research required to support the continuing process of urban planning, development and regulation.

This discussion of spillover costs also points up the major dilemma facing all those engaged in managing the urban environment, *problem interdependence.* The large urban region is a complex, dynamic and integrated ecosystem whose physical, biological and human components and whose economic, social and other problems are tied together by an infinite web of relationships. Congestion, blight and sprawl are problems *of* the city and should be approached accordingly. To tackle blight simply as a problem of decaying structures, core congestion solely as problem of overcrowded housing and transportation facilities, or sprawl as nothing more than a problem of land-use control is self-defeating and probably counter-productive. If these problems are to be resolved, they should be approached within a comprehensive context that recognizes all of their dimensions.[36]

Because of the diffused and pervasive character of the effects and costs of these problems, they are influenced by agencies of all orders and levels of government. In the area of economic, social and scientific activities, for example, federal policies concerning statistics, research, taxation, income security, health and manpower training can have an obvious impact on congestion, blight and sprawl, even though they may not be designed with these problems in mind. The same is true of the policies of provincial and urban government concerning activities in the same areas, or in the related fields of education, welfare and social services.

In the area of physical development, provincial and federal policies concerning housing, land assembly, urban renewal, transportation, public works, industry, trade and commerce and regional growth centres have a significant impact on the quality of the urban environment generally and congestion, blight and sprawl specifically. The positive and negative side effects of harbours, rail and other transportation terminals and corridors have been described above. Located near the core, they could play a significant role in reshaping the downtown environment of most of our major cities. The same is true of government buildings.

The impact of housing, land assembly and related policies on suburban development is equally clear. There is little doubt that federal, as well as provincial policies have played a significant role in bringing single-family dwellings rather than other forms of housing within the economic reach of millions of Canadians. Thus,

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[36]This is virtually a universal conclusion of all contemporary analysis of the urban process, whether focused on the environment or on poverty, transportation, housing, violence or any other major urban problems. Any number of references could be cited. A most relevant recent reference is A.H. Walsh, *The Urban Challenge to Government* (New York, Praeger, 1969). It reports the conclusions of a four year study of 13 metropolitan areas throughout the world. The study resulted in six books by various authors and was conducted by the Institute of Public Administration in New York with the support of the Ford Foundation. See also C.I. Jackson, *The Spatial Dimensions of Environmental Management in Canada* (Unpublished, 1970).

indirectly, the senior governments have encouraged not only necessary suburban growth but also its uncoordinated extension into rurban sprawl. Moreover, by insisting on minimum subdivision standards as a condition of financing, the federal government shares with provinces responsibility for the character and quality of the suburban landscape, and especially for its essentially uniform appearance from St. John's to Victoria. By manipulating these policies in the future, the federal government could continue to have a major influence on the character and environment of residential neighborhoods. Housing is only one component of the neighborhood, of course. Schools, hospitals, shopping centres, parks, access roads, streets, utilities – the whole range of neighborhood services provided by provincial and urban governments – will also have a crucial impact on the environment of tomorrow's neighborhoods.

Thus, problem interdependence and physical interdependence lead inevitably to jurisdictional interdependence. It seems safe to assert that these will remain important characteristics of urban environmental management. As mentioned earlier, the urban region is the appropriate level at which to undertake comprehensive urban planning and to regulate its implementation. Because of the nature and depth of federal and provincial activities concerned, however, both of these orders of government would have to be involved if urban planning and development were to be comprehensive. This is an inescapable corollary of the interdependence described above. If the policies of all orders and levels of government are not designed and harmonized to deal with congestion, blight, sprawl and related urban problems, their respective impacts could be partially neutralized, with consequent waste at all levels. At worst, they could be counter-productive, exacerbating the problems.

VISUAL POLLUTION

Canadian cities are rich in visual resources and the ingredients of beauty. All major urban regions in Canada are located on or near an ocean, lake or river and enjoy interesting topography, distinct seasons and diverse vegetation. Many have grand vistas and unique features and structures that reflect the heritage of the city, its province and our nation. Canadians have the wealth to translate these resources into beautiful and exciting cityscapes, yet we have not done so. Although our cities are beautiful in spots, their visual resources have too often been squandered. Waterfronts have been cut-off by industrial developments and transportation corridors; the downtown core and new residential neighborhoods have been stripped of trees, and attractive vistas have been hidden by billboards and parking lots. The result is oppressive and unattractive surroundings in many parts of the city. Once negative visual stimuli reach a level or intensity where they interfere with man's enjoyment of his environment, the state may be described as visual pollution.

Future trends provide grounds for both hope and despair. Each stems from the projections outlined earlier. As Canadians reshape and extend their urban environment over the next 30 years, they will have opportunities to ensure that the

results are more attractive and exciting than the environment they have inherited. These opportunities, coupled with rising levels of disposable income, higher average levels of education and increased perception of ugliness and beauty provide grounds for encouragement. On the other hand, the rapid rate of projected development could exceed the capacity of man and his institutions to guide it effectively, with further deterioration of urban visual resources.

Visual resources exhibit several characteristics relevant to the appropriate role of governments. Their most universal characteristic is pervasiveness. In the city, beauty is everywhere – in a skyline at night, on a tree-lined street, a shopping mall, a valley, the lines of a building or bridge. Ugliness is also everywhere. Offensive, distasteful images take the form of derelict buildings or litter in downtown areas; of gravel pits, junkyards and ribbon commercial development along suburban access roads; or of simply the oppressive monotony of repetitive architecture in new neighborhoods.

A second, and perhaps less appreciated characteristic, is the high cost of mismanaging our visual resources. Visual pollution has been shown to be a traffic hazard. Billboards have been proven to increase the frequency of road accidents. Traffic safety is improved by the elimination of tension and confusion caused by a jumble of identification, warning and directional signs. On the other hand, the costs of avoiding visual pollution are sometimes less than believed. The small, incremental capital costs of burying utility wires, for example, are generally more than offset by direct safety benefits, reduced damage due to weather, better service and lower maintenance costs.[37]

This leads directly to the third characteristic relevant to the management of the urban visual resource: total interdependence with all activities within the urban region. The beauty or ugliness of the urban environment reflects success or failure in the management of all urban resources and in the attention paid to color, texture, shape and location of all activities, private as well as public. It is intimately tied to everything in the urban region.

Related to this is the further characteristic that both the positive and negative spillovers of managing or mismanaging the visual resource are contained almost wholly within the urban region. It follows from this that the urban region is the appropriate level at which to apply most of the functions required to manage their visual resources, principally that of comprehensive urban planning.

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[37] Blumenfeld, "Environmental Aspects of Transport and Urban Development."

The need to control these functions at the urban level is reinforced by a further characteristic of the management of visual resources: its subjectivity. Esthetic standards are intangible, not well suited to enactment as laws or regulations. They vary with the individual, the locale, the cultural group and the time period. A building, street or neighborhood that offends one man may please another. What pleases in one era may offend in another. The visual aspects of urban planning and development reflect the inheritance, the current tastes and appreciation and the economic capability of the community in question. There should be no norm of visual quality, certainly not a national or provincial norm, however inspired it might appear. The visual aspects of planning and development in any community should be based on the aspirations of the citizens of that community and reflect their cultural diversity.

Although management of urban visual resources at the level of the urban region is desirable, it can be frustrated under current constitutional arrangements. There would appear to be two major obstacles. The first is the immunity of public and private agencies under the jurisdiction of the federal government, and public agencies under the jurisdiction of the provincial governments, from urban planning, zoning and other relevant bylaws. The extent of this immunity is not clear,[38] but it is probably sufficient to preclude the full application of urban esthetic controls to public buildings, railway, air and road transport terminals and corridors and public utilities. The second stems from the authority of federal and provincial agencies to impose national or provincial esthetic controls as a condition of receiving grants extended under their spending powers. National and provincial housing corporations establish certain types of standards as conditions of approval, such as their requirement that subdivisions be serviced by modern sewer and water facilities and otherwise meet minimum health standards. It might also be a proper use of this authority to insist upon certain esthetic standards that are universally recognized as desirable and that would not inhibit local creativity, for example, underground wiring. General application of national or provincial design standards, however, would stifle local creativity and result in urban monotony.

This is not to say that the provincial and federal governments do not have a role to play in achieving the full potential of urban scenic resources. They could play a leading role in three areas. The first is in establishing information systems and research, at the national and provincial levels. The second is in increasing public perception of beauty in urban design and of the direct and indirect costs of

[38] See Dale Gibson, *Constitutional Jurisdiction Over Environmental Management in Canada* (Unpublished, 1970). The immunity of agencies and enterprises under provincial jurisdiction would depend entirely on the jurisdiction granted by the province to urban government.

ugliness. The third is in establishing examples of the best in urban planning and design. This would require direct participation in planning in areas where the collective federal and provincial presence may be dominant. Their failure to participate could have two consequences. If public and private agencies under federal and provincial jurisdiction retain their immunity, the plans of urban government could be jeopardized. If these agencies do not retain their immunity and yet do not participate in planning, the potential positive impact of their structures on the urban environment may not be perceived or realized.

NOISE POLLUTION

Sounds have always provided an exciting dimension to urban life. Parades, open air concerts, street vendors and the varied sounds of human activity are an integral part of the attraction of living in a city. Today, however, noise constitutes a major form of pollution of the environment. Continual and often intense noise dominates modern man's existence, waking and sleeping, working and playing. Quiet is a luxury to be sought and guarded, often at considerable private and public cost.

Noise is really a form of waste energy. It is unwanted sound that exceeds the assimilative capacity of the ecosystem, with increasingly disastrous consequences. It is everywhere. In our homes, our ears are bombarded by the sound of labour-saving devices during the day and air conditioners at night. In the factory, production machinery generates an ever-increasing din. In the neighborhood, brief periods of silence are broken by gasoline-powered lawn mowers, passing trucks, motorized toboggans and low-flying jets. In the streets, there is a rising crescendo of noise both from new modes of surface transport and from larger and more powerful types of construction equipment, the compressor and air hammer, the pile driver and earth mover. Urban man can no longer escape from noise. The roar of expressway traffic, the jet plane and power mower even follow him to the country-side and seashore to invade the quiet of his most secluded refuge.

The proliferation of machines as substitutes for labour, as vehicles of transport and as objects of pleasure has brought new and louder sources of noise. Their concentration in urban areas, homes and factories has raised the background din inexorably. In the absence of effective counter-measures, the trend of noise levels is upward, at a very steep rate. It has been estimated that the overall level of environmental noise has roughly doubled in the past 10 years.[39] Urbanization,

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[39] Committee on Environmental Quality of the Federal Council for Science and Technology, *Noise – Sound Without Value* (Washington, U.S. Gov't. Printing Office, 1968), p.47.

industrialization and a market-dominated technology can be expected to bring forth an increasing variety of gadgets for the home, production equipment for the factory and transportation modes for private and public use. If the noise emissions of these machines are not controlled, the costs in future years could become intolerable.

The effects of noise on human health are of primary concern.[40] There is no doubt that prolonged exposure to noise produces hearing loss that is permanent and irreversible. A special symposium at the 1969 meeting of the American Association for the Advancement of Science heard evidence linking noise with heart disease, high blood pressure, damage to unborn babies and disorders of the nerves and glands, not to mention increased tension and irritability. The louder and more frequent the exposure, the greater the potential harm. The cost of this in human distress and greater inefficiency cannot be measured. The possible cost of compensation for industrial hearing loss, however, can be estimated. One estimate places possible compensation claims in the United States at $450 million per year, assuming that only 10 per cent of those eligible file a claim and that the average award is $1,000.[41]

Although the direct and indirect health costs are most serious, other costs can also be expected to reach alarming proportions. Building costs will rise as more effective sound-proofing becomes necessary for hospitals, schools, offices, apartments, factories and homes. This is now a major cost in a few areas. Compensation for outright damage to structures can also be expected to grow. When added to all of the other forms of stress in modern society, noise poses a serious and growing threat to the quality of Canadian urban life. A recent study commissioned by the City of New York revealed that its citizens suffered regular exposure to noise levels in excess of 85 decibels and that this threatened the well-being of the individual and the community.[42]

As in the case of visual pollution, an important characteristic of noise is its pervasiveness. With noise, however, this is a recent phenomenon. In decades past, the noise was fixed, the person could move. Zones of high-intensity noise were

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[40] Sound is measured in decibels, named after Alexander Graham Bell. Pure silence is zero on the decibel scale. Levels over 85 can damage hearing and result in deafness with long exposure. Many machines operate in this range or higher, as can electronic music. Levels around 130, the range of the sonic boom, will cause real physical pain. Since everyone is exposed, everyone suffers some hearing loss. By contrast, a New York hearing specialist, Dr. Samuel Rosen has found that aborigines living in an isolated part of south-east Sudan have hearing which is markedly superior with aging to that found in studies of residents of the United States. There are several factors which could cause this, the most obvious of which is the comparative quiet of the life environment of the aborigines. See Samuel Rosen *et al.*, "Presbycusis Study of a Relatively Noise-Free Population in the Sudan", *Transactions of the American Otological Society, Inc.*, L (1962), p. 149.

[41] *Noise – Sound Without Value*, p.34.

[42] *Towards a Quieter City: The Report of the Mayor's Task Force on Noise Control* (New York, 1970).

generally tied to restricted areas of land. With the advent of the airplane, the element of choice disappeared. Noise corridors were no longer attached to the land; they became separated things, superimposed on existing patterns – and on all new patterns – of land use. Supersonic transports will add a new dimension to this; even at high altitudes they can lay "boom carpets" 10 miles wide on the ground along their entire flight path.[43]

The urban audio resource is amenable to a wide range of management strategies and all will have to be employed if future noise levels are to be held within tolerable limits. They will have to be applied by all orders of government, each exercising those functions that can be most effectively applied within its boundaries.

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[43] U.S. Dept. of Interior, "Report to the Secretary of the Interior of the Special Study Group on Noise and Sonic Boom in Relation to Man" (Nov. 1968), pp.3-5:

> If commercial SST's are allowed to fly at supersonic speeds over the continental United States, the expected frequency and intensity of sonic booms would represent a significantly large increase in the noise level, and in the numbers of people exposed to intense noise. The numbers of SST's, expected sometime after 1975, would subject between 20 million and 40 million Americans under a path 12½ miles on either side of the expected flight tracks to 5 to 50 sonic booms per day. Each boom would be perceived by its hearers as equivalent in annoyance to the noise from a large truck travelling at 60 miles per hour at a distance of about 30 feet, or a four-engine turbo-fan jet airplane within half a mile of its take-off point. An additional 35 to 65 million people within 12½ to 25 miles of the flight path would be subjected to 1 to 50 booms per day of somewhat lower intensity, and 13 to 25 million more would experience 1 to 4 high-intensity booms. The response of the people in the 25 mile wide swaths swept by frequent and intense booms can be expected to be similar to that of residents of neighborhoods adjacent to busy metropolitan airports under the flight paths of planes taking off.
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> Reactions to sonic booms depend on their intensity and frequency. There is considerable initial adaptation following several months of exposure, but even after several years of experiencing the booms, most people find the booms objectionable or worse. Extensive research at Edwards Air Force Base, Oklahoma City, and in France, shows that, even after some years of continued exposure to sonic booms, 30 per cent of the people exposed to booms at levels anticipated for the SST would find the booms to be "intolerable" or "unacceptable" and an additional 50 per cent would find them "objectionable".
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> Complaints and damage claims derived from sonic booms have already forced restrictions on the flights of military supersonic aircraft over populated parts of the country, although the intensities of the booms created by such aircraft are less than those predicted from the SST, and although the frequency of the booms from military aircraft has been far less than that which would occur should the SST enter into full commercial service over the continental United States. Based on this complaint history, it is estimated that regular commercial overland supersonic flight would produce from 3 to 6 million damage complaints per year to public authorities. One out of 3 to 4 complaints would be followed by a property damage claim, and about half of these claims would result in an award of damages.
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> A conservative estimate of the expected continuing annual cost of the repair of damages to houses and other structures (not counting the cost of processing claims or inspection of damages) is at least $35 million, and possibly more than $80 million per year.

The range of possible noise management strategies fall into two broad categories. The first is control of the environment in which the noise is produced. This type of control can be most effectively applied at the level of the urban region and urban planning along with its associated functions is one of the most important instruments. In the future, it is clear that anticipated noise levels from streets, expressways, railways, airports and various types of industry should be important criteria both in the location of residential, commercial and industrial zones and in the location of specific buildings such as hospitals, schools and parks. Conversely, the planning of subways, expressways, railways, airports, heavy industry and other major sources of external noise should take into account their impact on existing residential, commercial, recreation and other land uses.

The regulatory strategies employed by urban governments could comprehend not only such activities as land-use control and building permits, but also the setting of local standards for permissive levels of noise by different activities in different parts of the region, requiring sound-proofing in certain types of buildings, and so on. Certain forms of research on problems unique to an urban region can best be undertaken at that level. In addition, of course, urban regions should both maintain an awareness of, and a capability to adopt, the results of research sponsored elsewhere, nationally and internationally. Finally, urban planning, regulation and research for noise management will require a variety of monitoring and other information systems within the urban region. Urban governments generally do not now possess this degree of power over sources of noise within their boundaries. The most important exemptions from their control, as mentioned in the discussion of visual pollution, are public and private agencies under federal jurisdiction and public agencies under provincial jurisdiction. Many of these, notably transportation terminals and corridors, are major generators of noise.

While control of noise levels *within* urban regions is essential, and can best be done at the level of the urban region, this control is relatively ineffective if not supported by other measures. Given the trends discussed earlier, it is unlikely that urban governments could keep up with the flood of new noise generators promised by an unregulated national and international technology. A second category of strategies is therefore necessary. These would be aimed at the primary sources of noise. They would involve reducing or eliminating the noise-producing features of a machine at the point of design or manufacture. Clearly, technological progress will not be sacrificed for silence. But technology must be brought to bear on the problems it creates, either by regulatory, incentive, or other measures. As we demonstrated in Part Two, strategies aimed at technological spillovers are inherently national and international. The research, regulatory, financial incentive and other strategies can therefore be best applied at this level.

SOLID WASTE DISPOSAL

Into Canadian homes flows a steady stream of food, clothing, appliances and motor vehicles. Out of them flow cans and cartons, garbage, broken appliances and

junked automobiles. This solid waste coupled with industrial scrap and the thousands of other residues of affluence, total more than 36 billion pounds annually. That is 1,600 pounds per person per year or more than 4.5 pounds a day for each Canadian.[44]

With growing affluence, the volume of solid waste has been increasing steadily. A half a century ago, per capita waste averaged only 2.8 pounds per day. If present trends continue, each Canadian will produce over five pounds of garbage per day by 1980, a figure that our American neighbors have already exceeded. By the year 2000 we could each be generating 7.5 pounds per day and the trend could still be upward.[45]

This growing mountain of waste is produced mainly in our urban regions and adds to the pressure on urban space, visual and other resources. A lot of it tends to spill over jurisdictional boundaries, either spread on the land or carried by air and water. Some of it is disposed of privately by industry and some of it thoughtlessly by individuals who litter our streets and landscape. But most of it is picked up and disposed of by urban government somewhere within or adjacent to the urban region.

This is already an enormous task for urban government. The precise dimensions of the problem vary from city to city depending upon its geography, climate and rate of growth, but every city's problem is intensified and compounded by two principal factors. The first is constant change in the composition of the waste. This stems in large part from a dynamic market-oriented technology that places the short-run convenience of consumers ahead of their longer term interests as subjects of the urban ecosystem or as tax payers. The trend towards non-returnable and non-degradable containers is a good example of this problem. Incentives to return bottles and jars for re-use could reduce the number of items disposed of by several millions.[46] Tin cans will rust in time but most plastics and other synthetic containers are more resistant to natural decay.[47] The second factor also stems from technology, but, in this case, a stagnant technology. In the absence of market incentives and public direction and support, the technology of waste disposal has hardly changed in the past fifty years.[48] Salvage companies do handle some waste commercially but, in terms of weight and volume, the proportion is minute. Even less is recycled by business and industry.

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[44] Data from information provided by Systems Research Group.

[45] *Ibid.*

[46] U.S. estimates place the number of bottles and jars disposed of at 135 per person per year. President's Council on Recreation and Natural Beauty, *From Sea to Shining Sea* (Washington, U. S. Gov't. Printing Office, 1968), p. 99.

[47] U.S. estimates indicate that annual per capita disposal of metal and plastic containers currently runs at 338 units. *Ibid.*

[48] *Ibid.*

In essence, urban government is now limited to two ancient options in deciding how it will dispose of its solid waste: to bury it or to burn it. Neither method provides a good solution. Yesterday, to bury it often meant to dump it casually in nearby low spots, or on unused land outside the city limits, or in a nearby river, lake or estuary. Today, this option faces increasing obstacles because of the filling of readily accessible sites within the city, because of the merging of suburbs with the city into larger urban regions, and because of a heightened awareness of the side effects of dumping waste in water or valleys and marshes which may have greater value if left in their natural state. The same is true of burning, which simply transfers the pressure from the land to the air resource and, in the process, often from one jurisdiction to another.

Within these constraints, our major urban regions face mounting costs for solid waste disposal over the next three decades. Projections to the year 2000 shown in Table 10 suggest that annual expenditures on operation and maintenance could triple, regardless of the method of treatment. Capital costs could rise proportionately, barring the introduction of new, less expensive technology. The projections suggest that a gradual shift to incineration, for example, would require a ninefold increase in annual capital, operation and maintenance expenditures, excluding expenditures on collection. Population growth, increasing amounts of refuse per capita, shrinking numbers of acceptable disposal sites and a stagnant technology combine to make solid waste disposal a costly and urgent environmental problem for our urban regions.

Solid waste disposal exhibits a number of characteristics relevant to the role of governments. Its total interdependence with all activities in the urban region is obvious. It flows from every home, business and industry in the urban region and any process of collection must begin there. The initial spillovers and their costs are contained wholly within the urban region and borne wholly by it. It follows again that the urban region is the appropriate level at which to apply the research, planning, development, regulatory, financial incentive and other strategies required for effective management of waste *collection.*

When it comes to *disposal* of solid waste, however, the question becomes considerably more complex. If the waste is disposed of by land fill within the boundaries of the region, the spillovers are again largely contained and the problem can be effectively managed within that spatial unit. But many urban regions are finding it increasingly difficult to secure accessible and acceptable land fill sites within their boundaries. If the urban region is forced to seek land fill sites outside its boundaries, the co-operation of other municipalities or of the province is necessary. Their agreement is also necessary to ensure that they are fully protected from and compensated for, the direct and indirect costs that they would have to bear. If the urban region dumps its wastes into the river, lake or estuary, it not only transfers some of its disposal costs to the citizens of other jurisdictions through water pollution, but it could also pose a threat to their health and destroy their recreation and other amenity resources. In fact, the dumping of urban domestic and

industrial waste, and the dredging of harbours, is a major source of water pollution. The same thing can happen from land fill, of course, both from run-off into surface waters and from seepage into ground waters. Household grinding of garbage quickly translates into liquid waste. If the urban region disposes of its solid waste by incineration, the resulting air pollution may also spill over into other jurisdictions. Thus, given present technology, the disposal of solid wastes, as opposed to its collection, can be of concern to more than one order or level of government.

It follows that where an urban region cannot manage its solid wastes wholly within its own boundaries, its plans should be subject to review and approval by the order of government that spatially comprehends all of the jurisdictions affected. This is the only way to ensure that the available alternatives have been considered, that all of the side effects have been identified, and that acceptable arrangements are made for those side effects that cannot be eliminated.

This means that, in respect of spillovers wholly contained within the boundaries of a province, the province should be in a position to require and, if necessary, participate in the inter-urban planning, development and implementation of solid waste disposal facilities. This is reinforced by another characteristic of solid waste disposal: the economies that can be obtained from large scale operations. Incinerators are generally uneconomic for cities of less than 55,000 people, and beyond that unit costs decrease rapidly with increasing scale.[49] Barring voluntary intermunicipal agreement, only the province is in a position to ensure that these benefits are realized. It is also reinforced by the growing possibilities of economically converting solid waste into useful products. Experience, mainly in Europe, offers many examples, but one will suffice: the conversion of solid waste into steam either for the generation of electric power or for the heating of buildings through central mains. As power utilities are generally under provincial jurisdiction this, too, necessitates joint planning among two levels of government in order to ensure that all alternatives are identified and evaluated.

Anticipated future growth of solid wastes prompted the United States National Academy of Sciences to warn in their 1966 report on Waste Management and Control that the only way the problem could be contained was by the recovery and recycling of much greater volumes. The development of new methods will require a greatly increased research effort. Research is being initiated in several countries. Some of it offers hope of major breakthroughs. Much of the needed research can be most effectively directed, sponsored or coordinated at the national level. The reasons for this were discussed in Part Two and will not be repeated here. Provincial and large urban governments, of course, also have a significant role to play in this area of research.

The above has been concerned with the broad category of strategies aimed at the management of solid wastes as they come out of the stream of production and

[49] Based on information provided by Systems Research Group.

consumption. It is probably inevitable that this will remain an important point of management. Future management of solid waste, however, will require the elimination of increasing amounts at the source. This may be achieved in part through positive and negative economic incentives, including financial and taxation measures. It will also require regulation. Where the industries concerned command national or international markets, incentive, regulatory and other strategies can be applied most effectively at the national level. Strategies focused on the source will also require research, not only into new technology but also into identifying incentive, regulatory and other management strategies that might be applied. Finally, various strategies could require different types of information systems to support research, and to maintain awareness of the changing dimensions of the problem.

URBAN WATER POLLUTION

The two remaining urban resources, water and air, pass freely within, between and over all spatial and political jurisdictions. Hence, all jurisdictions have a necessary role to play in their management. The following section examines the management of water from the limited perspective of the urban region. The supra-urban, provincial, national and international dimensions of water management and their implications for the role of governments are considered in Part Five. The management of air resources, as mentioned earlier, will be dealt with entirely in Part Five.

Water by its very nature may be used for literally hundreds of purposes. Although it is not often stressed, this characteristic obtains *within* the spatial boundaries of the urban region as well as throughout the reach of a major river basin. Furthermore, with each use within the region it becomes a carrier of waste and each time it is used the concentration and variety of wastes increases. Thus as urban homes, offices and factories use water for drinking and cleaning, it becomes a carrier of body wastes, detergents and other cleaning agents. As urban residents and their governments use water to irrigate lawns, parks and gardens and to wash streets, they introduce a wide range of pesticides, herbicides, fertilizers and salt. As urban industry uses water for cooling and processing, it also injects into it tens of thousands of chemicals and chemical compounds.[50] Most of our large urban regions were founded on harbours. Navigation remains a major and growing use within these regions, a use that through refuse dumping and harbour dredging, adds further waste, much of it within sight and smell of the city's heart.

Cities located on or near rivers and lakes use them for recreation and esthetic purposes. Clean water is beautiful to look at and delightful to walk beside. Parks and benches on a waterfront, a fountain in a square and a brook in a suburb help to

[50] According to O. C. Herfindahl and A. V. Kneese, *Quality of the Environment* (Baltimore, Johns Hopkins Press, 1965, printed for Resources for the Future, Inc., Washington), p. 17, there are some 500,000 organic chemicals known, of which most are synthetically produced.

make a city beautiful and to enrich the life of its citizens. Unfortunately, however, the increasing torrents of waste being dumped into rivers and lakes by *urban* residents and industry are destroying them for these and other uses *within* their own region. It is inevitable that urban residents and industry use water to dispose of waste and such use does not necessarily interfere with other water uses providing the natural ability of water to cleanse itself is not exceeded. Yet all of our major urban regions, from Halifax to Vancouver, have pushed the water resources within their boundaries beyond their assimilative capacity. This is neither necessary nor inevitable.

Unless massive corrective measures are taken quickly, the process of deterioration will continue to accelerate at a rate faster than the urbanization and industrialization trends themselves would suggest. During the first half of this century per capita use of water in urban areas more than doubled, increasing at a rate of about two per cent per year.[51] The average daily intake of water today is about 125 gallons per urban resident.[52] Domestic use has risen dramatically with the introduction of water-intensive appliances such as automatic washing machines and dishwashers. Current trends, reinforced by projected high income levels and the consequent widespread use of air-conditioners, swimming pools, and water-intensive innovations not yet on the drawing boards, could push per capita daily use to 200 gallons per day by 1980 and to between 300 and 350 gallons per day by 2000.[53] After use, approximately 80 per cent of the water withdrawn for domestic, commercial and industrial purposes is discharged into the sewage system and returned to the water course. Thus, if one superimposes these rising per capita use figures on the population projections for our larger urban regions, it is apparent that these regions face an enormous expansion of both water and sewage systems.

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[51] D. Cass-Beggs, "Water as a Basic Resource", in *Resources For Tomorrow: Conference Background Papers* (Ottawa, Queen's Printer, 1961), p. 181.

[52] This varies from region to region. Estimates in 1967 placed per capita consumption in urban areas for domestic, commercial and industrial use at 124 gallons per day, with regional variations as follows: Maritimes–117, Quebec–129, Ontario–125, Prairies–108, British Columbia–136: P. L. Timpany, "Water Supply and Sewage Treatment in Canada", *Water and Pollution Control* (August, 1967), p.46. The article is abstracted from the text of a paper prepared by Mr. Timpany and delivered to the Ninth Congress of the Union Panamericana de Asociaciones de Ingenieros in Mexico City, October, 1966.

[53] Some argue that technology can serve to reduce water demands as well as increase them. No doubt it can but, as experience shows, a dynamic market-oriented technology has served more to increase water requirements than to reduce them and there is no reason to believe this condition will alter measurably in the next 30 years. Levels of 350 G.P.D. by the year 2000 imply only a slight rise in the annual rate of increase. The city of Chicago used an average of 243 G.P.D. in 1969. City of Chicago Department of Water and Sewers, Annual Report 1969, p.24.

Table 10[a]

Projected Urban Expenditures on Solid Waste Treatment
(Millions of Constant Dollars)

	Annual Operations & Maintenance[b] Land Fill or Incineration			Incineration[c]			
	Low	#/Capita	High	% Treated	Annual Capital Investment	Annual O & M	Total
1971	241.8	4.6	246.1	25.0	14.0	23.0	37.0
1981	344.7	5.6	368.8	50.0	27.2	69.0	96.2
2001	623.5	7.6	764.0	100.0	72.0	287.0	359.0

[a]Compiled from information provided by Systems Research Group.
[b]Includes both collection and site costs. Projections are the same regardless of method of treatment, since both employ the same method of collection and this absorbs 75 to 90 per cent of the expenditures. Does not include capital. Assumes that per capita production of waste increases to 5.5 pounds per day in 1980 and 7.5 pounds per day in 2001.
[c]Site costs only. Does not include expenditures on collection. Assumes high population projection and increasing per capita production of waste.

The dimensions of the problem are even more staggering when one takes into account the large backlog of facilities needed by these regions to collect and treat their present volume of sewage. Table 11 shows that in 1961, over 80 per cent of municipalities in Canada with a population of 1,000 or over enjoyed modern facilities to *supply and treat water* for domestic and other users. When we look at *facilities for the collection and treatment of sewage,* however, the picture is quite different. Table 12 shows that less than 40 per cent of municipal residents were connected to sanitary sewers. Moreover only 60 per cent of urban sewage received any treatment whatsoever and only 30 per cent received secondary treatment.[54]

Given the urbanization trends outlined earlier, the situation in our larger centres is of greatest significance. Table 13 shows the current status of waste water treatment in the nine major urban regions. Quebec City and Montreal treat virtually none of their sewage, while Vancouver treats only 30 per cent. The remaining centres treat up to 100 per cent of their sewage, but only Toronto and Edmonton provide more than primary treatment. Moreover, the figures reflect "normal" operating conditions. During the spring run-off or following heavy rains, sewer systems that carry combined sewage and storm water can and often do overflow and deliver large quantities of raw sewage into the receiving stream, bay or ocean.

[54]It will be seen that these figures vary greatly from region to region. Thus over 90 per cent of urban sewage in Quebec and a similar figure in the Maritimes receive no treatment while only six per cent in Ontario and nine per cent in the Prairies receive no treatment.

Even where storm sewers are separate, surface run-off washes garden pesticides, lawn fertilizers, street salt and sediment directly into urban water courses without any treatment.

Table 11[a]

The Supply and Treatment of Municipal Water Canada and Its Regions: 1961

(Municipalities over 1000 Population)

Region	Dwellings Served with Running Water		Treatment Provided For Surface Water Consumed			Treatment Provided For Ground Water Consumed		
	Directly %	Thru Municipal Mains %	None %	Only Chlorination %	Filtration & Other %	None %	Only Chlorination %	Filtration %
Canada	89	80	3.1	28.0	68.9	32.2	27.0	40.8
Maritimes	77	56	1.7	73.5	24.8	42.6	46.2	11.2
Quebec	97	82	3.3	26.7	70.0	57.8	32.7	9.5
Ontario	97	82	0	13.9	86.1	38.3	32.8	28.8
Prairies	71	81	0.3	5.3	94.4	3.6	4.9	91.5
British Columbia	95	87	16.4	81.6	2.0	41.3	47.5	11.2

[a]P. L. Timpany, "Water Supply and Sewage Treatment in Canada", *Water and Pollution Control* (August, 1967), p.50.

This heritage of accumulated neglect must be added to the requirements projected for the next three decades. Together, they present urban regions with one of their most costly problems. These problems have been receiving more attention in recent years and expenditures on urban water treatment facilities have been growing at a rate of about 8.5 per cent per year nationally. This is faster than national population growth and may appear reasonable. Much higher levels of expenditure will be necessary, however, if urban areas are to catch up with their backlog and treat the waste water discharged by their new population and industry to minimum acceptable standards.

On the basis of available data it is not possible to provide projections of the *total* expenditures required. It has been estimated that the annual investment required to provide primary and secondary *treatment* facilities *only* would rise from just over $100 million in 1971 to between $240 and $380 million in 2001. The lower figure assumes that water use increases by two per cent per annum, the higher figure three per cent. This does not include the investment required to collect sewage and deliver it to the treatment facilities. Nor does it include the annual costs

Table 12[a]

The Treatment of Municipal Sewage in Canada and Its Regions: 1961[d]

	Population	Pop. Served by a Given Treatment			
	On Separate[b] or Just Sanitary Sewers[c] %	None %	Primary Settling or Septic Tank %	Lagoon %	Secondary %
Canada	39.6	41.2	20.7	7.9	30.2
Maritimes	30.8	89.9	3.5	3.4	3.3
Quebec	12.0	91.5	6.2	0.4	1.9
Ontario	40.2	6.3	30.6	4.1	59.0
Prairies	69.6	8.9	23.8	29.2	38.0
West Coast	71.0	46.3	29.8	12.8	11.0

[a]P.L. Timpany, "Water Supply and Sewage Treatment in Canada", *Water and Pollution Control* (August, 1967), p. 50.

[b]Municipality has separate sanitary and storm sewers.

[c]Municipality has only sanitary sewers but no storm sewers.

[d]*Primary Treatment* involves the removal of settleable suspended or floatable solids by mechanical and/or gravitational means; e.g., sedimentation, floatation, screening, centrifugal action. Depending on the process, it can remove between 30 to 50 per cent of the suspended solids, about the same percentage of biological oxidation demand, and between 25 and 75 per cent of the coliforms. With chlorination it can remove over 90 per cent of coliforms. *Secondary Treatment* involves the removal of dissolved, colloidal and suspended matter that is not amenable to physical separation through mechanical and/or gravitational means. Secondary treatment methods employ the activity of bacteria in the presence of oxygen. Depending on the process, it can remove 60 to 90 per cent of solids, a similar percentage of biological oxygen demand, and over 99 per cent of the coliforms. With chlorination, it can remove an even higher percentage of coliforms. *Tertiary Treatment* comprehends a range of processes that can remove up to 100 per cent of residual solids, biological oxygen demand, chemicals and coliforms. Processes focused on nutrient removal may presently remove up to 85 per cent of phosphates.

of operating and maintaining these systems. Annual costs of operation, maintenance and capital amortization could rise from an estimated $100 million in 1966 to between $765 and $904 million in the year 2000. These projections are displayed in Table 14. It should be noted that none of these projections include anything for tertiary treatment in a period when more expensive and sophisticated forms of tertiary treatment are becoming mandatory in order to maintain acceptable water quality standards.

The financial costs of restoring and maintaining the quality of our urban water resources will be high. The costs of continued inaction, however, will be immeasurably higher. A major proportion of these costs are external to a given

Table 13[a]

Status of Waste Water Treatment in Major Urban Regions: 1969

Region	Population (000's)	Population Treatment Number	Served by Facilities Percent	Wastewater Flow MGD[b]	Wastewater Treated Percent	Type of Treatment
Toronto	1,800	1,800	100.0	194.0	100.0	Secondary
Montreal	2,436	204	8.4	290.2	8.4	Primary: 2.6% Secondary: 5.8%
Vancouver	940	350	37.0	100.0	41.0	Primary
Ottawa[c]	300	300	100.0	40.0	100.0	Primary
Edmonton	430	420	98.0	37.5	100.0	Primary: 46.5% Secondary: 53.5%
Hamilton	300	300	100.0	60.0	100.0	Primary
Quebec	300	Nil	Nil	42.0	Nil	None
Calgary	370	365	98.5	38.5	100.0	Primary
Winnipeg	520	520	96.0	44.5	100.0	Primary

[a]Taken from figures compiled by the Public Health Engineering Division of the Dept. of National Health and Welfare at the request of the Economic Council of Canada, May, 1969. The department notes that "The figures shown in this table reflect normal operating conditions. Sewage volumes may be substantially increased by storm water and surface run-off particularly during the spring. Treatment may be adversely affected as a result. Where treatment is indicated, it does not necessarily imply that the type of treatment provided is adequate or satisfactory. Data shown are only valid for the period indicated and may not correspond to the present situation in all cases."

[b]Millions of Gallons per Day.

[c]Does not include Hull.

community and its industries, as witnessed by the gradual strangulation of Lake Erie by eutrophication, the mercury pollution of Lake Winnipeg and Lake St. Clair, and the destruction of beaches, fish-spawning beds and waterfowl habitat along our coasts and inland waterways. The implications of these direct and indirect external costs for the role of governments in water quality management will be considered in Part Five. This ability to transfer the costs of pollution to other jurisdictions no doubt goes a long way to explain foot-dragging in the past.

With the growth and fusion of urban areas, however, more of the conflicts between pollution and other essential water uses are occurring *within* the boundaries of a given urban region and more of the costs of pollution are borne directly by the urban residents concerned. The extent to which the costs of

Table 14[a]

Annual Expenditure for Municipal Waste Water Pollution Abatement Under Alternate Assumptions: 1966 – 2001[b]

Canada
(Millions of 1967 Dollars)

Period		Primary	Secondary[c] N=10	N=20	N=35
1966	O & M	8.8	19.7	19.7	19.7
	Total Annual	22.9	52.9	52.9	52.9
1971		8.2	52.6	43.7	39.9
		19.9	141.1	117.3	107.1
1976		7.5	69.6	70.5	62.6
		17.3	186.9	189.4	167.9
1981		6.9	89.6	101.4	88.8
		15.0	240.6	272.2	238.2
1986		6.4	113.2	124.9	119.1
		13.1	303.9	335.5	319.9
1991		5.9	140.2	152.0	153.7
		11.5	376.4	408.0	412.7
1996		5.4	170.3	182.1	192.1
		10.1	457.2	488.7	515.7
2001		5.0	203.6	215.4	225.5
		8.8	546.6	578.2	665.2

[a]Information provided by Systems Research Group.

[b]The Table is based on Systems Research Group preferred population projections and a daily per capita water intake of 120 gallons as of 1966 as well as a projected growth rate of 2% per annum.

[c]"N" is the number of years assumed to catch up on the present backlog of primary and secondary facilities; that is, the number of years over which municipalities presently with less than secondary treatment facilities would install such facilities to take care of their present waste load.

pollution are being internalized varies with the geography of the urban region. In this respect, our major urban regions can be grouped into two broad categories, those with rivers that flow through or near their heart and those located on lakes, tidewater estuaries and bays. Many of our major regions fall into both categories. Those in the first category receive waste from upstream communities but, given their relative size, most of the water pollution within their region comes from the region itself. Most of the pollution in the bays and waterfronts of those in the second category also originates within their region. Thus, the residents and industry of the Lower Fraser Mainland, viewed as a single urban region, are largely responsible for

the increasingly serious pollution both of the Fraser River flowing through the region and of the tidewater estuaries and bays that surround it. The same is true of Halifax, Montreal and Toronto. These and other similarly located regions generate most of the waste that pollutes their water resources. Their residents and industries are the main source of the high coliform levels and the complex combinations of toxic and other chemicals that threaten their health, close more and more of their beaches, and increase the cost of treating their water.[55] They are the source of floating debris that destroys the esthetic value of their waterfront and presents a hazard to their swimmers and boaters.[56] They are also the source of the bottom sediments that combine with other pollutants to further reduce oxygen levels and threaten the life of fish and other aquatic organisms. The costs to urban residents of polluting their own waters do not end here, however. By destroying the esthetic values and recreation potential of their rivers, waterfronts and bays, they reduce the attractiveness of life in their cities. This no doubt adds to the volume of the weekend exodus from the city as residents seek the unspoiled water resources of other regions. This, in turn, results in increased weekend traffic peaks, more congestion, a greater traffic toll and a heightened demand for still larger and longer expressways with all their attendant costs.

This analysis of urban water resources carries a number of implications for the role of governments. Most of them will be considered in the broader discussion of water resources in Part Five, but it is appropriate to introduce one of them here. The overriding implication of the above analysis is the need for unified management of water resources *within* the boundaries of the urban region and for integration with the management of other elements of the urban system. We have seen how water pollution begins where water use ends, in each and every home, office, commercial institution and industry in the region. Second, the planning, development and operation of urban sewer and water facilities should be integrated with

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[55] International Lake Erie Water Pollution Board *et al., Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River, Vol. I – Summary,* N.J. Campbell *et al.,* eds. (International Joint Commission, 1969), p.35. :

> Although coliforms are not normally regarded as pathogenic, the presence of members of this group in a water serves as an indication of the potential presence of the scarcer, and much more difficult to isolate, pathogenic organisms of the digestive tract, such as those causing typhoid fever, dysentry and cholera. Standards for water quality are based to a large extent on coliform concentrations.
>
> Data collected from the 1963-64 and 1966-67 Lake Erie studies indicate that coliform concentrations in the main body of Lake Erie are low .... However, several inshore areas do have bacterial pollution problems. *These areas are immediately adjacent to major population centres* and the mouths of the large tributaries entering Lake Erie .... (emphasis added).

[56] Floating garbage and rubbish are not generally present in large enough quantities to cause chemical or biological deterioration of water quality, or to cause a hazard to health. The problem is, nevertheless, a nuisance at water intakes and to shore property owners, swimmers and boaters. *Ibid.,* p.34.

that of other urban services – housing, streets, roads and utilities. This would not only ensure greater efficiency,[57] but also it appears necessary in order to promote sound patterns of overall development. The planning and development of water and sewer facilities can be an important tool for directing expansion within the region and ensuring that it conforms to an overall development plan. To be effective, however, it must be under integrated management and supported by other powers such as the power to grant or refuse vacant lands, the roads, power and other utilities required for their development. Under fragmented or single-purpose management, the uncoordinated extension of sewer and water facilities to vacant land can result in wasteful development as urban government is compelled to respond and provide the necessary roads and other services in a random fashion.

[57] Sewer and water facilities are particularly sensitive to economies of scale; unit costs fall off rapidly as size increases.

Chapter XI

Some Considerations Respecting the Role of Governments

It is apparent from the foregoing analysis that the amount of urban growth over the next 30 years could involve, in effect, the rebuilding of urban Canada. It is also clear that the pace and polarization of this growth could impose tremendous pressures on the resources of the urban environment. The expenditures required to cover the direct costs of this growth, while enormous, could be dwarfed by the public and private outlays required to cope with the side effects of excessive pressure on urban man and his natural environment. The projections suggest that the costs of these side effects could grow very rapidly unless Canadians prove able to develop and willing to apply strategies aimed at influencing both the effects of growth *within* urban regions and the forces leading to a rapid concentration of population into a relatively few large regions. This chapter will attempt to summarize some of the implications of the analysis respecting the role of government in these two areas.

ENVIRONMENTAL MANAGEMENT WITHIN URBAN REGIONS

At least three broad implications emerge respecting environmental management within urban regions. The first is that the urban region is the appropriate level at which to apply a wide range of environmental management functions, activities and strategies. By and large, however, it is those functions, activities and strategies associated with the preparation and implementation of comprehensive plans that can be most effectively applied at the level of the urban region. This stems from the demonstrated interdependence of the many elements of the urban ecosystem. Unified management of spatial and structural relationships within the urban region is called for by the number of interrelated activities and services competing for the same scarce space and other urban resources. It is called for because many of the most serious environmental spillovers of growth are contained wholly or largely *within* the region, even though they derive from demands on urban resources that are generated outside the region. Generally, it is within the urban region that the web of interdependent ecological, physical, social, economic and other relation-

ships can best be identified and evaluated and then translated into plans and development responsive to the needs and desires of the people most directly concerned.

Second, the foregoing analysis also demonstrates that many of the most serious environmental spillovers that are contained *wholly within* urban regions stem from activities of public and private agencies that fall under the jurisdiction of the federal and provincial governments. Under present jurisdictional arrangements, however, these agencies are generally immune from the planning, zoning, taxing and other relevant by-laws and regulations of urban government. Referring to agencies under federal jurisdiction, Gibson points out that the extent of their immunity from provincial (and therefore, urban) legislation is somewhat uncertain, but that "the courts seem willing to apply it quite broadly."[58] Agencies under provincial jurisdiction, of course, are as immune from urban planning controls as the province chooses to make them, since urban government derives all its powers from the province.

Thus, the activities of federal and provincial departments responsible for airports, expressways, bridges and public buildings are effectively immune from urban planning and related environmental controls. So are the activities of federal and provincial Crown enterprises responsible for harbours, railway terminals and corridors, power plants, telephone and other utilities. So also are the activities of some private enterprises incorporated under federal and provincial laws, such as railways and utilities. Taken together, the economic, spatial and physical significance of these activities in any major urban region is substantial and can determine the quality of major components of its environment. In the form of buildings and other structures, such as harbours and railways, these activities can determine the character and alternative uses of land in the downtown core. As points of traffic generation, they can influence the design of streets and access roads, determine the success of public transit and, in the case of airports or power stations, they can effectively sterilize large areas for other uses through noise, air and water pollution. As providers of power and telephone services, they can determine whether downtown streets and residential neighborhoods have the appearance of landscapes or wirescapes. In short, while these activities cannot ensure the success of an urban plan, they can certainly preclude it.

In light of the foregoing analysis, one has to ask whether there is any overriding reason for exempting a federal or provincial enterprise, or a private enterprise subject to federal law, from the application or urban planning and environmental controls that do not substantially interfere with its activities? On the face of it, the continued immunity of federal and provincial activities from urban planning and other related environmental strategies appears to conflict

[58] Dale Gibson *Constitutional Jurisdiction Over Environmental Management in Canada* (Ottawa, Queen's Printer, 1970).

unnecessarily and undesirably with the evident need for unified management of structural and spatial relationships within the urban region.

Third, the analysis not only highlights the physical interdependence of the urban region. It also provides repeated illustrations of problem interdependence and indicates how both lead inevitably to jurisdictional interdependence. In view of this, and the nature and depth of federal and provincial activities in urban regions, it seems evident that both of these orders of government would have to be involved in urban planning and development if it is to be comprehensive and effective. Appendix 3 reveals some of the dimensions of the federal presence in our larger urban regions as employer, developer and taxpayer. Appendix 4 shows the activities of various federal agencies, the functions that they exercise in respect of each activity and the constitutional bases of their presence. It reveals that 22 agencies are present in a significant way. Most of them have a strong actual or potential impact on five categories of activities crucial to the quality of the urban environment: spatial area, land use, housing, transportation and recreation. Furthermore, they exercise all of the management functions in respect of most of their activities. There are, for example, 18 departments involved in information systems, 15 in research, 11 in planning within the urban region, 19 concerned with the development of urban buildings from homes to transportation terminals and facilities, and 15 involved in financing urban development.

Although the mix of functions and activities may change in time, the presence of the federal government as employer, developer and taxpayer in our larger urban regions will almost inevitably increase in the future. So will the range and penetration of the activities and functions of federal departments and agencies in the management of the urban environment. The same surely applies to the presence and activities of agencies of the provincial government. If the urban policies and programs of all orders of government are to be designed and harmonized with environmental and related urban problems in mind, it is difficult to avoid the conclusion that the relevant federal as well as provincial agencies would have to participate actively in comprehensive urban planning.

EXTERNAL FORCES INFLUENCING URBANIZATION

At the beginning of this Part, a distinction was drawn between the external forces generating the growth of urban regions and the effects of this growth on and within urban regions. The rate of growth of an urban region is determined by strong and pervasive forces largely beyond the control of the urban region itself. It is determined partly by the degree to which the urban area is an integral part of the national and international urban network. It is determined partly by policies governing the nation's economic and social structure, immigration and migration, international and inter-urban transportation, and research and technological innovation. These determinants are influenced, to the extent they can be influenced at all, by broad powers in the hands of federal and provincial governments.

The preceding discussion revealed the extent to which environmental management problems within urban regions stem from both the rapid pace and the concentration of urban growth. The nine largest urban regions, for example, could absorb over two-third of the total projected population growth and commercial and industrial development over the next 30 years. Since they would be the main repositories of future growth, of course, they would enjoy more of its benefits such as higher monetary incomes, greater leisure time, better education and a greater choice of life styles. But they would also suffer most of its major costs. They would carry the greatest burden of financing the social capital required by new population. Their people and resources would endure the greatest pressures of growth, with their pervasive, hidden and costly side effects.

Fortunately, Canadians in common with few other peoples are in a position to choose their urban future. They have the knowledge, power and wealth to modify these trends if they wish to do so. Throughout the world to date, two basic approaches have been proposed to bring the pace and location of population expansion under social direction and to alleviate urban overgrowth. The first involves regional economic decentralization and the deliberate encouragement of new or existing growth-centres. This is being attempted in Canada by the Department of Regional Economic Expansion in co-operation with the provinces. In Canada, the primary goals of this approach are related to reducing regional economic disparities, not to reducing urban overgrowth. The second approach involves the encouragement of existing or the establishment of new satellite cities, within the commuting orbit of larger urban regions. The recent concept for the Toronto-centred Region announced by the Government of Ontario includes elements of this approach.[59] The U.S. Department of Housing and Urban Development recently suggested a pattern for new community development in the United States, allocating approximately 30 per cent of projected growth into satellite communities. Commenting on this, it observed that,

> Under existing trends . . . the lion's share of new communities would occur . . . in or near the greatest metropolitan areas. It is precisely in these regions of urban concentration that new communities are critically needed to combat urban sprawl, to protect land and water resources, and to provide in a more orderly way for large scale population growth.[60]

It is not the intention in this paper to argue the merit of these prescriptions or to offer others. Given the nature and strength of the underlying forces, however, it is apparent that measures to influence population shifts between and within provinces would require the concerted efforts of both federal and provincial governments. Moreover, to be effective, these efforts would have to occur within a

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[59] Government of Ontario, *Design for Development: The Toronto-Centred Region* (Toronto, Queen's Printer, 1970).

[60] U.S. Dept. of Housing and Urban Development, "Trends and Projections", p. 21a.

coordinated framework of national and regional goals. The reduction of urban overgrowth in certain regions would be only one of a range of goals.

There is no empirical list of all of the factors external to a region that influence people to enter or leave the region. Presumably one could establish a link between population movements and every activity that serves to make one region more or less attractive than another. This would embrace the whole sphere of government. Six categories of activities, however, appear to represent the most significant determinants of the process: economic policy, social policy, technological innovation, transportation, immigration and interregional mobility.

Only the federal government is in a position to apply differential economic and social policies in order to encourage or discourage the movement of population *between* provinces. Provinces, of course, may design tax, fiscal and spending measures that differ from similar measures in other provinces, in the hope of retaining or attracting people and industry. *Within* a province both the federal and provincial governments can apply differential economic and social policies to encourage or discourage the shift of population into selected urban regions. A provincial government is able to employ essentially the same arsenal of tax, fiscal and spending measures *within* the province as the federal government. In addition, both are able to employ a number of other related economic and social measures.

Federal and provincial policies affecting transportation, immigration and internal migration are three major determinants of urban growth. The terminals of international, national and inter-urban transportation have a strong influence on the location, function and growth of cities. Immigration has recently accounted for one-third of the annual increase in our labour force and most of it has gone into our principal cities. Immigration policies therefore provide a means of affecting aggregate movements of population into urban regions. The importance of research and technological innovation to urban environmental management has been cited repeatedly. Its many dimensions, including its institutionalization and internationalization were discussed at length in Part Two.

The forces leading the rapid pace and concentration of urban growth in Canada, therefore, could be subjected to a marked degree of influence and even manipulation by strategies applied at both the federal and provincial level. Indeed, they would have to be if these forces are to be guided with environmental and other goals in mind. Unless these strategies were applied within a reasonably coordinated federal-provincial framework, however, it is doubtful that any interprovincial or intra-provincial population distribution objectives could be fully realized.

Finally, it seems clear, for environmental and other reasons, that strategies aimed at influencing urban overgrowth in certain regions will compel a greater degree of control over the use and development of land between urban regions. Clearly, the province has the crucial role to play in this because of its jurisdiction over property rights, and because of its responsibility for a whole range of related activities. An important implication of this analysis is that the province is in the

best position to undertake those functions necessarily associated with the preparation and implementation of regional plans that are supra-urban and sub-provincial, separately and jointly in co-operation with adjoining urban regions and with the federal government. Again this includes but cannot be limited to determining and regulating the functional relationships – location, scale and phasing – between the main physical components of an inter-urban, regional system. It may also include delegating to urban regions the responsibility to administer objectives, standards, policies and programs necessary to manage supra-urban but sub-provincial environmental spillovers.

PART FOUR

RURAL AND TERRITORIAL AREAS

Chapter XII

The Vast Domain

Beyond the urban regions lie the expanses of rural and territorial Canada, a vast domain encompassing an infinite variety of lands and waters from the grandeur of southern lakes, prairies and mountains to the remote wilderness of the Arctic tundra. It would be difficult to exaggerate the importance of this immense territory, more than 95 per cent of our nation's surface area. It provides desired life styles for a significant segment of Canadians. It supplies the food, fibre, minerals and timber for the growing urban-industrial complexes in Canada and abroad. It sustains the habitat for much of the continent's wildlife and waterfowl and it includes Canada's great vacation lands.

When the first colonists settled along the St. Lawrence, all of Canada was virtual wilderness. The early settlers carved farmlands and townsites out of the woods. Later, in the east, west and north they cleared bushland, turned prairie sod, established timber operations and developed mines. Given their small numbers compared with the vastness of the land, these activities did not appear significant. Since the turn of the century, however, and especially since World War II, the scale and magnitude of these activities have multiplied steadily. The horse-drawn scraper has given way to the bulldozer, the axe to the power saw, and the dog team to the tractor train. Today, technology has brought the remotest resources of our nation within reach of the world's urban-industrial complex.

This activity, added to the spillovers from urban regions, has already overwhelmed many of the different and often delicate ecosystems of rural and territorial areas. From the dust bowls of the Thirties to the fishing bans of the late Sixties, Canadian history is full of examples of careless resource use or overuse leading to deterioration and destruction. In the future, the unrelenting appetite of world commerce and the projected growth in population, income and leisure time, will greatly increase pressures on rural and territorial resources, and on the all-important life-chain that they support.

The opportunity exists to meet demands for increased quantities of food, fibre, minerals and other commodities while restoring and maintaining the quality of our resource heritage and the balance of complex ecosystems. This will require a

much greater concern for environmental management than Canadians have displayed in the past, however. As in urban regions, an effective system of environmental management in rural and territorial areas requires first a recognition by all orders of government of the appropriate and vital role of each, and second a willingness to co-operate and support each other in the exercise of these roles.

Throughout the following analysis, the broader notion of resources set forth in the discussion of urban regions is retained. Environmental deterioration is viewed as stemming from the excessive pressure of human activity on these resources. Rural and territorial resources – land, visual, audio, air and water – receive and try to assimilate the spillovers both from activities based in these areas and from those centred in urban regions. In the following discussion, the nature of the spillovers into all five resource categories is examined, but the discussion is concerned mainly with the implications of spillovers on land resources. Visual, audio, air and water resources are mentioned only briefly. Air and water are treated cohesively in Part Five.

There are differences in the treatment of urban regions and rural and territorial areas. In discussing environmental management within the context of urban regions, focus was provided by the fact of physical concentration. In Part Four, this focus is missing. There is no self-evident unifying element about economic activities based on the use of land in our rural and territorial areas. Geographically, they are as diverse as the country itself and they impinge in different ways on an infinite number of ecosystems. Because of this, we discuss environmental management of rural and territorial land and related audio and scenic resources, within the context of four major categories of activities. These are agriculture and forestry, surface and subsurface mining, surface transportation, and recreation and wildlife. Each of these activities possesses in itself a considerable unity which is reflected in the strategies employed to deal with it. Each of them, too, possesses a number of characteristics of significance to the role of governments. These will be drawn out in the analysis.

AGRICULTURE AND FORESTRY

About eight per cent of the land surface of Canada is presently used for agriculture and a further 48 per cent is forested.[1] The principal use of this land today is the production of food and forest products, but other uses are growing in importance. Ever larger acreages are being converted to urban development and to roads, expressways and associated commercial uses. Agricultural and forested lands are increasingly needed to satisfy demands for outdoor recreation. At the same time they must continue to provide a haven for wildlife and waterfowl and to protect and conserve the sources of water for our rivers and streams.

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[1] Calculated from data in D.B.S., *Canada Year Book, 1967* (Ottawa, Queen's Printer, 1967), p. 441.

Not all of these uses are compatible and choices between them have to be made. Subject to some public influence and regulation, these choices are now made largely by market forces which, for the reasons discussed in Part One, do not reflect non-market environmental values. In the future, with increasing demands for all uses of agricultural and forested land, the number and varieties of conflicts are bound to multiply, as are the number of choices to be made. These choices will no doubt continue to be made largely through the operation of private market forces. If future choices are to reflect environmental values, however, the operation of market forces will have to be tempered by a greater degree and variety of planning, incentive, regulatory and other strategies supported by a wide range of information systems and research.

The production of food and fibre will continue to be the principal use of agricultural and forested land. Agricultural production could double over the next twenty-five years while the production of forest products could triple during the same period.[2] This greatly increased production may be achieved by various means. Some are apparent now while others will emerge from new and presently unforeseeable technological and other innovations. The means by which production may be increased can press on rural resources in different ways. Some can raise the cost of land and threaten its various uses, including that of production itself. Some can increase the pressure on other resources. Alternatively, the means of increasing production may be compatible with various uses, to a greater or lesser degree, depending on what they are and how they are applied.

The various means of increasing production may be grouped under two general categories, devoting more land to production or making more intensive use of available land. These two general methods are examined briefly below. The discussion illustrates the nature and dimensions of some of the environmental management problems that can result. It also serves to draw out certain implications for the roles of the different orders of government.

The earliest method of increasing food and fibre production in Canada was to devote more land to agriculture and forestry. This option is still open. There are millions of acres of undeveloped land in Canada which, under good management, would be suitable for the production of food and wood products. New technology, improved grains, trees and animal varieties and other innovations in the future can be expected to make economic the development of areas that are now marginal.

Depending on conditions unique to each area, new land development could produce significant environmental benefits or it could induce huge environmental costs. The drainage and dyking of low-lying marsh areas can, for example, make land available for crop production, and at the same time reduce health hazards by destroying the habitat of disease carriers and pests. At the same time, however, it can destroy valuable waterfowl and wildlife habitat and increase flood hazards

[2] See Table 9.

downstream. Widespread clearing of trees can have the same negative effect and can destroy sometimes irreplaceable natural environments and recreational opportunities. Widespread reforestation, on the other hand, can not only increase forest production potential but also reduce silting of rivers and reservoirs and increase recreational opportunities[3] and wildlife habitat. Some of Canada's best agricultural land is located near our most rapidly growing urban regions. In the future, conflict between the continued use of this land for agriculture and its use for various forms of urban development will intensify. Some authorities have concluded that, if the present pattern of urban sprawl is permitted to continue until the year 2000, there will virtually be no land left in commercial agriculture in the Lower Fraser Valley, in Southern Ontario between Cobourg and London and in the Lower St. Lawrence Valley between Cornwall and Three Rivers.[4] Alternative lands suitable for urbanization do exist in these areas, although the financial outlay required for their development may be somewhat higher. Alternatives for agricultural production in these areas do not exist. The question is whether the environmental, social, economic and other benefits that would be gained by preserving this land for agriculture exceed the costs of not using the land for urban development and of developing alternative locations for urban growth. This question, in various forms, is involved in all land-use conflicts and it can be answered only within the context of comprehensive regional planning.

The second general method of increasing production is through more intensive use of land and other resources. The development of large-scale, concentrated livestock feeding enterprises is a current example of this. The environmental costs involved do not require much elaboration. A moment's reflection satisfies one that animal feedlots for poultry, cattle, hogs and sheep generate a tremendous volume of waste, the equivalent of large human concentrations.[5] These wastes press on all rural resources. Spillovers into the land and air resources are more or less contained and hence amenable to control strategies applied at the local level.[6] Spillovers into the water resource may be more serious. Difficult to confine and treat, feedlot waste is washed raw into drainage basins. It can seriously overload small tributary streams and add greatly to pressure on rivers and lakes.

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[3] These benefits can be of immense importance to people living in semi-arid regions such as near the Gardiner Dam and Lake Diefenbaker.

[4] A.D. Crerar *et al*, "Urban Growth and Resources", in *Workshop A, Resources For Tomorrow: Proceedings* (Ottawa, Queen's Printer, 1962), pp. 191-95.

[5] One beef cow produces 87 pounds of waste per day. National Research Council, *Canadian Code for Farm Buildings (Farm Building Standards) 1970.*

[6] In Ontario a three-man committee has drawn up a code of practice aimed at controlling air pollution in rural areas. Essentially, the code sets out guidelines for the distance of livestock buildings from roads, neighbouring farm homes or residential areas adjoining rural areas. It also recommends the number of livestock a farmer should raise on a certain acreage. Acreage figures have been based on the amount of land necessary to dispose of manure from a certain amount of livestock or poultry. See Government of Ontario (Dept. of Energy and Resources Management), *A Suggested Code of Practice for the Establishment of New Livestock Buildings,* etc. (1970).

More intensive use of land may also be achieved through the application of chemical fertilizers, pesticides, insecticides, rodenticides, fungicides and biocides generally. This means of increasing agriculture and forestry production is having the most serious and widespread implications for environmental management.

There can be no doubt about the tremendous immediate benefits that man has gained from the use of fertilizers and biocides. There are abundant data demonstrating that fertilizers and biocides have vastly increased the yield and quality of agricultural and forest crops. More subtle but equally significant gains stem from reducing crop-yield fluctuations and reducing the period it takes forests to mature. This translates into benefits ranging from lower-cost production to reduced financial risk and less worry on the part of farmers and foresters. From some points of view, the effects of biocides on human health throughout the world have been even more important than their effects on crop yields. Large reductions in the incidence of malaria and some other diseases have been effected through the use of DDT to control mosquitoes and other carriers of these diseases. The resulting improvement in human welfare has been enormous.

While it is difficult to underestimate these short-run benefits, they have been bought at a long-term cost to man and his natural environment, the dimensions and ramifications of which are only now beginning to unfold. Indeed it is hard to imagine a clearer case of the phenomenon described as "technological boomerang". It is well established that many fertilizers and biocides present an acute direct threat to man and to various biological species as well as to parts of the biosystem upon which they depend. This macabre fact stems from a number of characteristics of fertilizers and biocides, most of which are relevant to the roles of different orders and levels of government.

Global dispersion of compounds found in fertilizers and biocides, is becoming increasingly well documented. The two media of transmission are water and air. Nitrates and phosphates in fertilizers, for example, are a major source of the nutrients that feed algae polluting the Great Lakes, the Qu'Appelle, the Okanagan and many other streams and rivers throughout Canada and the world. Man has long been a resident of these drainage systems, a part of the food chain and in harmony with it. In recent decades, however, he has spread his agricultural and now his forest lands with fertilizers, mainly nitrates and phosphates, which are washed into streams and lakes where they play havoc with ecosystems.[7] Man not only applies fertilizers; he also applies biocides to control insects, rodents, fungi and many varieties of plant and forest diseases. These, too, are washed into our streams and lakes and oceans where they enter the food chain and are carried great distances.

The fact that compounds in biocides can also be dispersed through the atmosphere is not so obvious and has only recently been documented. Indeed one of the major questions that perplexed the scientific community for years about the

[7]For a discussion of the process of eutrophication, see Part Five, pp. 162-63.

deaths of birds of prey was that, although they seemed to be causally related, they were spatially so separated. The dispersion of DDT from application sites was thought to be due to water transmission of soil particles and to the movement of creatures through the food chain. Within the last few years, however, small quantities of DDT were discovered in the air over London, England and later elsewhere including Toronto. The concentrations were minute and not enough to arouse the curiosity of chemists but wildlife biologists noted that the concentrations were equal to those which, under other circumstances, had killed larvae and fish fingerlings. It has since been concluded that DDT co-distills with water molecules sufficiently to be carried into the full water and weather cycle and distributed over the globe through the atmospheric system and the main ocean currents.[8] Atmospheric drift has now been demonstrated for other biocides including 2, 4-D.[9] This has important consequences for control of fertilizers and biocides. Although some nations are beginning to regulate their use, and even to ban certain compounds such as DDT, dieldrin and aldrin, in other nations their use is accelerating. The remarkable dispersion qualities of these compounds will ensure global distribution as long as they are being used extensively anywhere.

Biological magnification, another characteristic of fertilizer and biocide use, was described in Part One. Biological magnification refers to the ability of plants, animals and aquatic organisms to concentrate certain compounds, and to the increasing concentration of these compounds in plant and animal tissue as they proceed up the food chain. It is well established that the few compounds that have been tested are present in man and animals and in the plants we eat. DDT residue has been found in Arctic polar bears and Antarctic penguins, dieldrin and aldrin in farm animals, and mercury in Alberta's pheasants and partridge. Data obtained over the last decade by the Food and Drug Directorate, Department of National Health and Welfare suggest that on the average the fat of Canadians contains from four to five parts per million of DDT, a level that has not changed significantly over this period.[10] This amount is similar to the values reported from the United Kingdom.

The persistence of hydrocarbon biocides is another characteristic that has been documented repeatedly. Some remain active in soil for years. DDT residue is reported 15 to 20 years after exposure. With repeated application and repeated

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[8] J.A. Keith, "DDT and Birds, A Case History in Pollution", a paper presented to the joint annual meetings of the Entomological Society of Canada and the Entomological Society of Ontario, August 26, 1969.

[9] R.W. Fyfe, "Pesticides and Wildlife", a talk given to the Fish and Game Association of St. Albert, Alberta, January 13, 1970, and also confirmed by the Director of the Canadian Forest Research Laboratory, Canadian Forestry Service, Edmonton, in a private communication, Aug. 10, 1970.

[10] Unpublished data compiled by W. Ritcey, G. Savary and K. McCully of the Food and Drug Directorate, Dept. of National Health and Welfare. See also J. Robinson, "The Burden of Chlorinated Hydrocarbon Pesticides in Man", *Canadian Medical Ass'n Journal,* 100 (1969), p. 42.

washing into drainage basins, they accumulate in food crops, in the tissue of animals and birds, fish and other aquatic species, reaching concentrations exceeding legal permissive levels.[11] The danger posed by this is heightened by the great variation in the tolerance levels of different organisms to different compounds and the scanty knowledge we have concerning their long-term side effects. Of great concern is the unknown long-term effect of prolonged exposure. This concern is not only with pathological effects, such as cancer and damage to the nervous system, but also with possible genetic damage. Some mercurial compounds and hydrocarbons damage chromosomes and this could cause massive genetic damage in future generations, long after the original exposure.[12] There are so many forces at work, however, that it will always be hard to associate a specific genetic effect with a particular cause.

The effects of these characteristics on wildlife are equally acute and, for many species, potentially disastrous. It is now established that at certain locations the reproduction rates of some bird populations have been greatly reduced through eggshell thinning and other phenomena. Some are now threatened with extinction. Extensive fish kills in Europe and the United States have been traced to biocides. In Part One, it was noted that minute concentrations of biocides, such as DDT, can significantly diminish the rate of photosynthesis of the small aquatic plants that produce 70 per cent of our total oxygen. This has caused scientists to speculate on the ecological consequences of a marine disaster involving a spill of biocides. The long-term build-up of persistent pesticides in our oceans could have the same effect.

To the characteristics of global dispersion, biological concentration, persistence, variation in tolerance levels, and limited knowledge of long-term side effects, one must add two more, the enormous increase in worldwide use of fertilizers and biocides and the rapid change in the varieties, mixes and targets of their compounds. The former stems from a growing population that demands ever larger annual increments in agricultural and forest products and forces an ever greater dependency on fertilizers and biocides. The rapid growth in the number and variety of compounds stems in part from a fertile technology. In the case of biocides it also stems from the constant need to shift to new forms as target pests and bacteria adapt genetically and become resistant to the old.

This discussion of agriculture and forestry illustrates again the interdependence of environmental management problems and the need for all

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[11] International Lake Erie Water Pollution Board *et al., Pollution of Lake Erie, Lake Ontario, and the International Section of the St. Lawrence River, Vol. I – Summary,* N.J. Campbell *et al.,* eds. (International Joint Commission, 1969), p. 12: The Board recommended that "compatible and coordinated programs designed to effectively control pollution from herbicides and pesticides be implemented by 1972 and that substitutes be found for persistent toxic chemicals and their use encouraged."

[12] See Göran Löfroth, *Methylmercury: a Review of Health Hazards and Side Effects Associated with the Emission of Mercury Compounds into Natural Systems* (Stockholm, Swedish Natural Science Research Council, 1969).

governments in a federal state to possess the powers required to develop and apply those strategies most effectively discharged at their respective levels. The application of fertilizers and biocides to increase production generates spillovers that are supra-provincial and supra-national in scope. Only in rare instances are they confined to a county or a province. The spillovers from their use in Canada are felt in other countries and vice versa. This problem, then, requires strategies developed nationally, involving the full range of functions from research, planning and financing through to preventive, curative and punitive regulations as well as the monitoring and other information systems required to support them. Many of these strategies might be applied under the umbrella of international agreements. Functional efficiency and other criteria might require that many of them should be implemented by delegation through agencies of provincial governments.

The other means of increasing production discussed above generate environmental spillovers that are contained largely within a province or a sub-region of a province. This includes the side effects of increased pressures on land resources and, to some extent, on air and water resources. It follows that planning, incentive, regulatory and other strategies concerning these means can be effectively applied at the provincial level. This is supported by the fact that in the case of land management many of the powers required derive from proprietary rights. It may well be, of course, that scale and other criteria will require a continuing, flexible federal role in research related to these aspects and, where federal lands are involved, in planning and development.

SURFACE AND SUBSURFACE MINING

From the fragile tundra of the Territories to the exposed rocks of the Shield and the soft sediments of the Prairies, Canada possesses a vast quantity and variety of mineral and petroleum resources. Industries based on this national wealth have been and will be important to its economic growth and development.

Unfortunately, in transforming these resources into economic wealth Canadians have paid very little attention to long-term environmental consequences. It was, and still is, accepted practice to mine as cheaply as possible and in a manner that provides the greatest financial profit to the producer. Such practices have left behind a legacy of scenic devastation and acid-laden waters. While past actions may be excused on grounds of ecological ignorance, pioneer values or technological limitations, these reasons can no longer be accepted. We now perceive the dangers; we have the knowledge to avoid them, and our value systems increasingly demand that we do so. If the different orders of government concerned fail to adopt, or lack the power to adopt the strategies required to avoid these dangers, the prodigious withdrawals of surface and subsurface minerals expected over the next three decades could result in the cumulative degradation of our environment.

Generally speaking, mining involves two phases: first, prospecting or exploration to discover, delineate and prove the ore body or reservoir, and second,

the actual extraction or recovery of the deposit.[13] Factors such as the accessibility, chemistry and configuration of the deposit, and the climate and topography of the location, influence the methods employed in each phase. They also determine the nature and extent of the spillovers into the surrounding environment. All of the resources with which we are concerned receive these spillovers, although the intensity and specific side effects vary greatly from site to site.

Generally it would appear that the side effects from surface mining pose the greatest future threat to environmental values. Subsurface mining, however, can involve huge environmental costs, both during the exploration and the exploitation phases. Unless closely controlled, these costs could become intolerable, especially in the north with its limited ability to assimilate pressures and restore itself. The great variation in side effects, their possible future dimensions and their implications for the role of governments can perhaps best be illustrated by a brief discussion of four categories, quarrying, coal, hard rock and petroleum and natural gas.

Rock quarries and sand and gravel pits tend to be located near their large markets. These ubiquitous mines consume surface space at random, without regard to alternative uses or environmental values. Often they are located immediately adjacent to roads and highways where they mar the landscape, contribute to stream sedimentation, and create traffic hazards. Sometimes, within or near urban regions, they are located close to residential areas. In addition to visual ugliness, they contribute to local air, noise and water pollution and thus create a health hazard for worker and resident alike. Depending on their location, then, quarries and pits can produce serious external effects to be borne by the community at large. Without effective planning, incentive, regulatory and other strategies, the side effects and their costs can be expected to multiply over the next three decades. While no direct projections have been attempted, the future dimensions of the problem can be inferred from the projections indicating that the construction industry could quadruple its output by the year 2000.[14]

The strip-mining of coal differs from open-pit mining of gravel and stone in that it is usually conducted at sites relatively remote from large urban centres and from its markets. Its side effects are essentially the same but its scale is larger — much larger. The practice of surface mining for coal and other minerals has had a harsh effect on parts of the Canadian environment. The miner going into a mine shaft with his pick and shovel has been supplanted in many areas by the operator of a gigantic twelve-story, earth-moving machine that gouges out the land and minerals

[13] The subsequent processing and marketing of the minerals may take place at the mine site or elsewhere depending on the economics of each industry and of public policy. From the point of view of environmental management, this phase was covered implicitly in the treatment of industrial growth in Part Three.

[14] See Table 9.

hidden underneath in huge, ton-sized bites.[15] In flat terrain a series of cuts as deep as the over burden plus the deposit leaves a landscape that resembles an immense washboard. In rolling or mountainous country, cuts dozens of feet deep can continue for miles along a hillside. In series they can leave a slope with rims and benches resembling a gigantic stairway. Soil and broken rock can slide down the slope creating scars, and run-off can produce deep gulleys and carry sediment into nearby streams and rivers.

During the past few decades in Canada, public policy affecting coal mining has been focused mainly on the social costs of a declining industry. In the future, however, especially in the West, public policy will be more concerned with controlling the spillovers of a vigorous and rapidly expanding industry. Rough estimates of acreages to be surface mined over the next two decades have been deduced from forecasts recently published by the National Energy Board.[16] Their study anticipates a major increase in western Canadian production to satisfy exports to Japan and expanding requirements for thermal-electric generating plants in Canada. Saskatchewan's annual production may increase sevenfold in 25 years, from 2.1 million tons in 1966 to 14.1 million tons in 1990; Alberta's could rise tenfold in the same period from 3.4 to 32.4 million tons, while British Columbia could experience a twentyfold jump from 1.1 million tons to 21.8 million tons.[17] Making certain assumptions respecting seam thickness and other factors, one can translate these projections into rough estimates of surface acreage to be disturbed annually for coal mining.[18] By 1990, Saskatchewan can expect stripping to occur at a rate of 1,200 acres annually, Alberta 2,200 acres annually and British Columbia 1,000 acres annually.[19]

Hard-rock mining operations can also have serious consequences on environmental resources. As a rule, however, hard-rock mining occurs in areas well removed from major urban regions and hence there are few people to observe and suffer the direct consequences. In many areas only the mine employees, their families and a few others suffer the full impact of noise and local air pollution or

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[15] From the limited viewpoint of a mining company, surface techniques offer real advantages. They make possible the recovery of deposits which, for physical reasons, cannot be mined by underground methods. They provide safer working conditions. They usually result in more complete recovery of the deposit and, most significantly, they are generally cheaper in terms of unit cost.

[16] National Energy Board, *Energy Supply and Demand in Canada and Export Demand for Canadian Energy 1966-1990* (Ottawa, Queen's Printer, 1969).

[17] *Ibid.*, p. 65.

[18] "It is assumed that all mining will employ strip methods. Some of this mining may be carried out by underground methods which would reduce the amount of stripping. In the Rocky Mountains area many of the coal seams dip at angles up to 45°, which would also tend to reduce the stripping areas. The actual area disturbed at any one time would vary considerably according to the mining techniques." Source: private communication from the National Energy Board, January 30, 1970.

[19] *Ibid.*

notice the cumulative disfigurement of the landscape caused by minehead slag heaps. As in the case of most other activities, the pressure on land, scenic and audio resources is contained within a relatively small area and so is the resulting deterioration. The same is true of pressure on air resources. Mine operations and mine waste piles, can be a source of airborne dust and a serious health hazard to employees and local residents. Unlike processing and manufacturing operations, however, they do not spill over large areas.

The severity of discharges from coal and hard-rock mines into water resources depends on the mine location, local topography and other factors. The run-off from waste piles and underground workings may contain acid or alkali or excessive concentrations of dissolved substances such as iron, manganese, and copper, as well as the salts of metals such as zinc, lead, arsenic, copper and aluminium.[20] Erosion of waste piles and access roads can result in large qantities of sediment being discharged into streams.[21] Acid drainage and sedimentation can affect the use of waters in several ways. It can greatly increase the cost of downstream treatment for domestic and industrial use. It can preclude recreational uses. Even in minute concentrations, salts of metals such as zinc, lead, arsenic, copper and aluminium can kill fish and other aquatic life and destroy their food-chain and habitat. The effects can be contained within a country or province or they can be supra-provincial or international in scope. No estimates are available of the present extent of the side effects of mine drainage in Canada, but they are known to be serious in several areas. With mining activity expected to quadruple by 1990,[22] government and industry will have to devote much greater attention to these problems.

This is also true of the negative environmental effects of petroleum and natural gas production. Canadian petroleum production of one million barrels per day in 1966 is expected to rise to between 4.1 and 5.5 million barrels per day in 1990. During the same period, natural gas production could jump from 1.3 trillion cubic feet per day to between 4.9 and 9.5 trillion cubic feet per day. The difference between two 1990 figures for oil and gas reflects the anticipated potential production from Canada's "frontier areas" including the Arctic.[23]

In all mining activity but especially in petroleum and natural gas development, serious environmental spillovers occur during both the exploration and the exploitation phases. Many forms of geophysical activity require that long slash lines be cut through vegetative cover in a grid pattern and that roads and trails be constructed to haul supplies to drill sites. Success brings more intensive and concentrated development of roads, transport facilities, storage depots and living quarters. Marketing can require the construction of large surface or subsurface

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[20] United States Department of the Interior, *Surface Mining and Our Environment* (Washington, U.S. Gov't. Printing Office, 1967), p. 56.
[21] *Ibid.*, p. 63.
[22] See Table 9.
[23] National Energy Board, *Energy Supply and Demand in Canada*, p. 10.

pipelines or docking facilities for supertankers. These activities and their hundreds of variations press on all environmental resources.

To date most of Canada's petroleum and natural gas fields have been developed in temperate regions and, where strict regulations have existed, it has been possible to ensure that side effects did not as a rule exceed the assimilative and restorative capacity of the resources concerned. Thus access to sites for drilling or pipeline construction on public or private lands, clean-up after use, and compensation for damages to fences, crops and soil, have been controlled by land use and other related regulations. The danger of oil, gas and salt water seeping into fresh groundwater aquifers or, in the case of off-shore drilling development, into our lakes and oceans has been prevented by strict regulation of drilling practices. Air pollution from flare gas has been similarly controlled.

Large scale petroleum and natural gas and mineral development in the Arctic presents a whole new set of problems to those concerned with environmental management. Most of these problems stem from a harsh climate and unique topography, combining long dark winters and very low temperatures with soil permanently frozen to a depth of 600 to 2000 feet except during the short summer when a thin upper layer may thaw to form a soft surface. These harsh features greatly reduce the number of plant and animal species that can live in the Arctic. They also diminish their rates of growth. In temperate zones roads and trails are bulldozed and land cleared for pipelines in the knowledge that, with reasonable care, plants and trees will re-establish themselves and heal the scars of man's manipulation. This is not true in the Arctic. In undisturbed areas of permafrost, for example, a delicate temperature equilibrium exists between the top of the permafrost and the ground surface. Any change in the natural insulating cover, such as the removal of a moss layer by a bulldozer, can upset this balance and cause severe thermal erosion and settling. Arctic plants and animals are much more sensitive to environmental changes than their temperate cousins. Once the balance of nature is upset, it takes far longer to become re-established. Ecologically, perhaps the most serious potential threat to the Arctic stems from the possible sinking or breaking up of a supertanker spilling thousands of tons of heavy crude on the water and shoreline. This special threat to the northern environment will be discussed more extensively in Part Five.

Canadians cannot expect to enjoy their present level of material goods production without developing mines and extracting petroleum and natural gas and, in the process, generating pressures on all environmental resources. But we can ensure that these pressures do not result in the overloading and deterioration of any resource. In the future, mineral exploration and development should be viewed as a comparatively short-term use of land which, with sound management can be made compatible with other uses during exploitation, and with proper rehabilitation afterwards can be made available for other purposes. This means that environmental values must be reflected in the choices made daily during the course of exploration, development and operations. It means that the costs of ultimate

restoration of the land must be anticipated at the beginning of each phase of development and provision made for adequate revenues to cover such costs. It means incentives and regulations to ensure this, at least to the extent that environmental values and restorative costs are not reflected in the operation of the private market.

Since the pressures of mining activity on land, audio, scenic and air and water resources are mostly local, the main planning, financial, incentive, regulatory and other strategies can be effectively applied by or through provincial governments. This includes spatial and structural planning in all its forms. It includes various types of regulations that may be needed, not only land-use regulations but also regulations governing restoration plans for surface and subsurface mines including advance security deposits or other types of inducements to ensure implementation of such plans. Many of the required powers derive from proprietary rights. In addition, of course, governments will need to undertake research and to establish monitoring and other information systems. This applies equally to the federal government in the northern territories.

The federal government also has an essential national role to play. Policy formation by all orders of government could be facilitated by continuing national inventories of the nature and extent of mining pressure on various environmental resources. The increasing variety, scale and impact of abuses to land, air and water resources and the biological life they contain, and the common characteristics of many of their side effects, could call for research at the national level, perhaps coordinated with other countries. Other essentially federal powers could be used to support provincial governments that might find it difficult to apply their regulations against large national or multinational companies. Export permits, for example, could be made conditional on companies conforming to provincial plans and regulations governing the operation and restoration of surface mines.

SURFACE TRANSPORTATION

In the environmental management of surface transportation, the corridor is of prime importance. This is a band of variable width, within and without the right-of-way, that is most likely to come within the cone of vision of the user. It has two elements: one is the facility itself, the railway, canal or trackbed; the other is the land-use pattern adjacent to the right-of-way.[24]

The location and design of inter-urban or rural transportation facilities in Canada have been concerned mainly with speed and economy rather than harmony with the surrounding environment. Financial considerations have also dominated the development of ancillary corridor services, often without informed regard for environmental values or the comfort and safety of the users.

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[24]The President's Council on Recreation and Natural Beauty, *From Sea to Shining Sea* (Washington, U.S. Gov't. Printing Office, 1968), p. 201.

There are a number of exceptions to this in all fields of surface transport. Environmental and social values are now receiving more attention in the rehabilitation of inland canals and railways and in the construction of new highways. Transportation planning is proceeding within increasingly comprehensive contexts that at least permit the incorporation of scenic, social, ecological and esthetic values in the evaluation of alternatives.

Over the next three decades, Canadians will transform much of their inter-urban and rural transportation systems. It will be recalled that the projections in Part Three indicated that inter-urban passenger travel by private vehicles could double by the year 2000 while travel by bus and rail could triple. Similarly, commodity transport by road could triple while rail and water transport quadrupled and pipeline transport increased by nine times.[25]

Each transportation mode will affect rural resources in slightly different ways. Of greatest importance, perhaps, is their actual or potential impact on the rural landscape in all its variety. The design, placement and operation of these new and expanded facilities can destroy a beautiful countryside, or can preserve or enhance it. There is often a choice. A freeway or a rural road can provide unobtrusive access to the landscape, blending with the natural topography and revealing its beauty to many who could not otherwise see it. The same is true of a railway or a canal. These scenic and social values can be easily sacrificed, however, and they will be sacrificed if Canadians continue to insist that, in the event of conflict, they should always be traded off in favour of higher speed or reduced construction costs.

The volume of construction anticipated over the next three decades promises other opportunities and other threats. If the past is a guide, these new and expanded systems and their increased density of traffic will generate an elaborate set of side effects. One example of this, the external costs imposed by vehicles on each other through space congestion, was discussed in Part Three. An increasing volume of highway traffic would also generate roadside development intended to service this traffic – filling stations, diners, garages, motels, beer parlours and dozens of other facilities, some essential and some not. In and around these strips, and on the outskirts of communities small and large, other forms of visual pollution converge. Roadside litter tends to concentrate there.[26] Commerical signs, giant billboards and rural wirescapes dominate the landscape. Drivers and passengers are subjected to a steady of impressions and distractions that can be offensive at best and dangerous at worst. These side effects, with their high social costs, are neither

[25] See Figure 7 and Table 7.

[26] The President's Council on Recreation and Natural Beauty, *From Sea to Shining Sea,* p. 217:

> It costs the American taxpayers an estimated $100 million a year to pay for picking up highway litter. State highway agencies alone spent $25 million in 1966. Litter costs even more in indirect costs; littered countryside reduces the pleasure of recreational outings and travelling, and nails and glass puncture automobile tires.

necessary nor inevitable. In all provinces there are highways that attest to the fact that, with good planning and strict regulation, necessary facilities for the trucker and tourist can be provided in a manner that is attractive both esthetically and commercially.

The same kinds of side effects are generated by railways. They are also found along canals and, with the anticipated rapid growth in pleasure boating and yachting, there will be increased demands for marinas and other ancillary service facilities. These, too, can be carefully planned and regulated to enhance the natural features of the waterway and add to the comfort and pleasure of the boater. Random corridor development, on the other hand, will surely threaten to destroy many of the environmental values that users come to enjoy.

The most rapidly growing mode of goods transportation is pipelines.[27] If it should prove feasible to transport solids through pipelines, their development will receive an additional impetus. Underground pipelines are the most attractive form of goods transportation from the point of view of environmental management. They can follow the natural contours of the land. Once the temporary disturbance of construction is over, pipelines can be covered and the land restored to its original or other purposes. They do not press significantly on any resources, nor present a permanent obstacle to man or wildlife.

Under certain conditions, however, even pipelines can pose a serious and widespread threat to environmental values. Advanced plans to construct a four-foot diameter, 800-mile long, two million barrel-per-day pipeline across Alaska from Prudhoe Bay to Valdez have been interrupted by the United States government in order to permit an assessment of the possible environmental side effects. The dangers stem from the unique nature of the Arctic environment mentioned earlier. The oil comes out of the ground at temperatures of 150°F. or more. If the pipe is laid several feet underground in permafrost, the permafrost would thaw to variable depths up to perhaps 50 feet and create a permanent marsh or canal. Depending on its location, the surface canal could interrupt the migration routes of Arctic game. A pipeline laid on the surface of the ground would have the same effect. Pipelines in Siberia have been built on stilts high enough above the ground to prevent melting of the permafrost and to permit wildlife freedom of movement. Pipeline fractures present another danger, not only to land and game and, indirectly, to people and industry dependent on the game, but also to water resources and aquatic life. Pipeline fractures occur under the best of conditions. The earthquake zones, instability of permafrost and temperature extremes found in the north, would magnify the risk factor. Past experience suggests that "it is reasonable to expect in this area of severe environmental conditions that one major pipeline failure could occur every three to five years. Depending on location, the severity of the failure, how soon the failure is noted and corrective action taken, the relative availability of repair equipment and personnel, the weather conditions at the time, the location of

[27] In terms of volume, see Table 7.

line (safety) valves and the nature of the terrain in the vicinity of the break, as much as 150,000 barrels of oil could be released."[28] Clean-up of the affected surface and water resources under harsh climatic conditions would be extremely difficult and it would be decades before damaged resources were able to restore themselves. The above discussion of the environmental aspects of rural and inter-urban surface transportation suggests three characteristics of significance to the role of governments. First, with the exception of local, municipal and county access roads, the four major transportation modes, highways, railways, canals and pipelines, are all at least provincial in scale and, increasingly, they are national and international. Consequently, they are all managed by large provincial of federal agencies or by large private corporations under direct federal or provincial regulation.

The second characteristic is that most of the positive and negative side effects of these four modes on rural land, scenic and audio resources and their costs are generally contained within fairly limited corridors, certainly within the spatial limits of a province or the northern territories. It follows that the relevant strategies such as spatial and structural planning, financial incentives or preventive and curative regulations can be applied most effectively at the provincial or territorial level. It must be borne in mind, however, that some side effects on the health, safety and comfort of man and other subjects of the biosystem may be fairly widespread, and their costs can easily be transferred from the local jurisdiction through which the corridor passes into other jurisdictions.

The third characteristic is that the technology of transportation is changing rapidly and in quite unpredictable directions. Consequently the nature and spatial extent of the side effects are also changing. In the above, for example, only the traditional modes of surface transport have been discussed. All of them require and are confined to a developed corridor. Recent years, however, have seen the emergence of a large number of "all-terrain vehicles". The most prominent of these is the motorized toboggan. Over one million such vehicles have been sold in North America in the past decade, 35 to 40 per cent in Canada. Free to roam virtually anywhere, they have brought with them a new dimension of side effects: invasion of rural privacy, harassment of wildlife, destruction of parklands and afforestation sites, intensive noise levels dangerous to the driver and irritating to others, and conflicts with other forms of winter recreation. The development of such vehicles, with their obvious consequences for the environment, reinforces the need for continued research on the environmental side effects of transportation and on ways to manage them. For the reasons discussed in Part Two, this research and its underlying information systems may require international as well as national or provincial efforts and hence could be of concern to all orders of government.

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[28] Private communication from National Energy Board, January 30, 1970.

OUTDOOR RECREATION AND WILDLIFE

Recreation activities are distributed throughout the non-urban environment. Increasingly efficient modes of transportation have facilitated the widespread dispersion of recreational activities and their environmental consequences. Environmental deterioration in urban regions acts as a spur to this outward movement, but the prime motivation is no doubt the desire for outdoor recreation and a deep-seated bond between Canadians and their natural landscape. Canadian recreation concepts are biased toward the rural. Indeed attachment to the image of nature is so strong that many feel their only "true" recreation hours to be those hours spent in rural areas. Many Canadians will continue to spend their weekends out of the city, as well as their longer holidays. Twenty per cent of their leisure time is now spent beyond the city and it is projected that over the next 30 years this could grow to 25 per cent.

This demand bears upon several different rural environments: the rural-agricultural environment, the environment of wilderness forest and associated lakes and streams, and the large lake and marine environment. The majority of Canadians can draw on at least two, if not three, of these environments in their weekend leisure time periods.[29] The variety of recreational activities is great, from sight-seeing and hunting to skidooing and ice fishing.[30] Each of these activities makes its own demands of the environment and exerts its own pressures on it. Because the attributes of the environment are key determinants to the type of activity pursued, activities tend to be similar in similar environments. In lake country, near urban areas, cottage use predominates. If there are too many cottages around a lake, water pollution from human wastes may result, or the area may become so developed that it loses its original attractions. In some wilderness areas, hunting or fishing may predominate. If the area becomes too developed, pollution from upstream communities and industries may reduce or destroy the resource or, less likely with modern management, hunting pressure may exceed the productive capacity of the habitat. This tendency towards concentration of certain leisure-time pursuits in each of the above environments, highlights the interconnections between recreation and environmental quality. The following paragraphs provide a few illustrations of these relationships as they concern land, water, audio and scenic resources.

The first, and in many ways, the greatest impact of recreation on the rural environment is its occupation of the land surface. From 1966 to 2000, the share of non-urban resource-based recreation in the national leisure time budget is projected to increase four times from 5.9 billion hours to 23.6 billion hours.[31] The leisure

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[29] Information provided by W. M. Baker, Park and Recreation Planner, 62 Sloley Road, Scarborough, Ont.

[30] See pp. 78-82 concerning the relationship between recreation and the urban environment.

[31] Information provided by W. M. Baker.

hours spent at cottages could more than double. In 1966 there were an estimated 400,000 cottages in Canada.[32] It seems reasonable to anticipate an annual growth rate in the number of properties of three per cent, which would mean about 12,000 new cottages a year.[33] The leisure hours spent in national and provincial park use may increase by an even greater percentage. In 1966, national parks registered 11.4 million visitors and provincial parks, 26.5 million, on a combined base of approximately 41 million acres. Demand could increase six times by the year 2000 giving a total of between 200 and 250 million visitors.[34]

Providing the necessary resources for these and other recreation uses is complicated by three vital factors: accessibility, attractiveness of the area and its sustained carrying capacity. The population is in the south, increasingly concentrated, with high time and dollar costs for travel. It seeks convenient land, water and shoreline for a variety of pastimes. A vast proportion of our hinterland, including tundra and non-productive forest areas, does not possess either the physical assets or the biological carrying capacity for park use. Less than 10 per cent of our productive forest lands are likely to be suitable for park development.[35] In terms of wildlife resources, it is the southern fringe of our forests that are the most productive; and fish resources also are significantly more productive in southern waters. It is in fact, the streams, lakes, valleys, scarplands and rolling hills of the rural-agricultural environment that have the greatest capability for sustained recreation use.[36] This same area experiences the most intense competition from other uses.

Park and cottage development are not the only recreation uses competing for scarce land resources in the years ahead. Hunting may experience the same sixfold rate of increase.[37] It now competes with other land uses, often alarmingly – as rural residents in the hunting season will attest! The satisfaction of this growing demand could involve a number of things. It could involve increasing the production of game by restoring and improving existing habitats and by adding to them. Increasing the supply of game may prove difficult for two reasons. First, as observed above, wildlife productivity is generally greater in our southern, temperate areas where it experiences increasing competition from other land uses. Second, even with the addition of new habitat areas, increased production may not result unless accompanied by measures to improve overall environmental quality. All but one of the 66 endangered species of wildlife currently listed are threatened not by overhunting but by deterioration in the quality of their habitat, stemming from economic activities.[38] In the long run, if the supply of game cannot be increased,

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[32] *Ibid.*
[33] *Ibid.*
[34] *Ibid.*
[35] *Ibid.*
[36] *Ibid.*
[37] *Ibid.*
[38] *Endangered Wildlife in Canada* (Ottawa, Canadian Wildlife Federation, Feb., 1970).

alternative measures could involve reducing the demand, either by increasing the price of hunting or by steadily reducing the number of licences issued, or both.

There are vital links between land- and water-based recreation demand. The use of water necessitates the use of land; the congestion of land affects the quality of water. The growing recreation pressure on non-urban water resources can be illustrated by two currently popular uses, boating and angling. In 1966 there were nearly one-half million privately-owned boats in Canada and the popularity of this activity shows no sign of slackening. Certain waterways, such as the Fraser estuary and the Gulf of Georgia, the coastal waters of the lower Great Lakes, the Ontario canal systems and the St. Lawrence, now support heavy pleasure-boat activity. This will almost certainly increase as a result of United States as well as Canadian demands. In 1966 some 86,000 foreign pleasure craft entered Canada, an increase of more than a quarter in three years.

Boating is one aquatic sport that is not seriously affected by the quality of the water. It is more affected by surface conditions and by the scenic values of the shoreline. Power boating affects water quality, however, by spillage of oil and wastes. It can also affect the audio and scenic values of a recreation area, positively or negatively depending upon your point of view. These spillovers and their side effects are all locally contained.

Sport fishing is analogous to hunting in many ways. Although widely distributed over our inland and marine waters, southern areas have much higher productivity rates. The demand is also concentrated in the south and projections suggest that it could increase sixfold in the next 30 years.[39] This assumes, however, that supply can be increased significantly. As in the case of hunting, increasing supply depends not only on restoring and adding to present fisheries, but also on improving overall environmental quality. If supply cannot be increased, demand will have to be reduced through economic forces or regulatory measures.

One of the most attractive non-urban resources, ashore or afloat, is quiet, the absence of the sustained sounds of human activity. To escape the noise of the urban regions, is one of the common objects of rural recreation. Ironically, the means of escape by some is often a reason for escape by others. Those who retreat from the city to the forest by a motor toboggan are the conveyors of noise pollution to snowshoers and cross-country skiers. Similarly, the outboard engine and the pontoon-equipped aeroplane can be the means of escape for some and the source of noise for others. While quiet is a vital quality of the rural environment for some forms of recreation, noise is a common product of other forms of recreation. Noise is an irritant for rural inhabitants; it limits the recreational use of an area and it often affects wildlife. It is apparent that the management of the audio resource should be included in the management of any rural environment for recreation and wildlife uses.

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[39] Information provided by W. M. Baker.

Other compelling attractions of the various rural environments are their scenic resources. These are generally perceived to be the comparative absence of the visual imprint of human activity. But recreation, itself, as a manifestation of human activity, is often a threat to this aspect of environmental quality. The over-development of cottage potential on a lake or river, the super-abundance of tourist services along a beach, or roadside services along a scenic drive are examples of the perennial threat recreation demand poses to visual resources. A major dilemma of park planning is how to accommodate the maximum number of visitors and yet preserve the scenic resources. Those who seek wilderness values may find these values threatened by even the appearance of another human being. The provision of an adequate range of recreation opportunities necessitates the consideration of rural scenic values, and the preservation of these values demands the integrated planning of recreation supply and demand.

A number of conclusions emerge from the above discussion. The first is the threat that recreation poses to itself. Each wildlife species has a limit to its reproductive capacity. Each recreation area, regardless of whether it is based on land, water, audio or scenic resources, or on a combination of all four, has a limit to the use it can support. Overuse can reduce or destroy the recreation potential of the resource. The second is the interdependence of recreation uses within any given environment. The third is the interdependence of recreation uses and other uses. Depending upon the resource and the use, this interdependence may be local, provincial, national or international in scope. The final characteristic is jurisdictional interdependence. This may take several forms. It could be said, for example, that a federal-provincial-local complex now exists to supply the various leisure time needs of Canada's population. If the facilities in one part of the system are overstretched, the demand shifts to another. A national park in an area not served by provincial parks or day-use facilities, for example, could be subject to demands that threaten its prime values. A provincial park or conservation area an hour's drive from a large urban region without adequate recreation facilities, could be subject to pressures that it was not designed to accommodate and that its resource base cannot support. Recreation must be managed on a multi-jurisdictional basis if we are to avoid simply shifting its environmental and other costs from one jurisdiction to another.

Chapter XIII

Some Considerations Respecting the Role of Governments

Throughout the foregoing a number of characteristics of significance to the role of different orders of government have been identified. Three general considerations seem to stand out. First, the discussion demonstrates that a wide range of environmental management functions, activities and strategies can be most appropriately and efficiently applied at or below the spatial level of the province. The conflicts between demands for various uses of rural resources on the one hand and the necessity of maintaining rural amenities on the other are widespread and growing. The spillovers from the principal fields of economic activity on rural land, scenic and audio resources are contained wholly or largely within the boundaries of a province (or the northern territories), although they may derive from demands generated or technology developed outside the province. The implications of this are parallel to and support those already stated in Part Three: the provinces are generally in the best position to undertake those functions, activities and strategies associated with the preparation and implementation of comprehensive plans. Again this includes, but cannot be limited to, determining and regulating the relationships between the main physical components of rural development. And it includes those functions necessarily associated with the preparation and implementation of comprehensive plans, such as research and information systems.

Second, many of the environmental side effects are contained within small areas or within large areas that are relatively uninhabited and cannot support local government. Furthermore, with the rapid increase in the nature and scale of rural-based activities, the spatial location and area of impact are undergoing constant change. These changes and their implications for the environmental responsibilities of local government can be most easily identified and evaluated at the provincial level.

Third, some of the effects on rural resources stem from the activities of agencies under the jurisdiction of the federal government. This is true of railways,

canals and pipelines. These activities occur largely on lands owned by the federal government or by public or private corporations under federal jurisdiction. Yet they often generate a demand for ancillary activities which locate on adjacent private or public lands. Unplanned and unregulated, these ancillary activities can induce spillovers that affect the use of and impose heavy costs on the primary facility. Alternatively, the location or expansion of new transportation corridors or other major facilities under federal jurisdiction can affect the use of and impose heavy costs on pre-existing related uses of land under provincial jurisdiction. This interdependence raises questions similar to those posed in Part Three concerning the immunity of public and private agencies under federal jurisdiction from environmental controls imposed by provincial governments.

PART FIVE

THE TRANSCENDENT RESOURCES: AIR AND WATER

Chapter XIV

The Atmosphere

In Part Five, we turn our attention to air and water resources, air resources in this chapter, water resources in the next. These resources transcend all of our spatial-political entities and all of our economic and social activities. They are the ultimate receptacles of most of man's waste. This role is beginning to threaten seriously their primary role – to support life and maintain the balance of the ecological system.

There are two reasons for discussing the environmental management of air and water resources separately. First, their management possesses a spatial dimension lacking in that of land, visual and audio resources. Spillovers into them are not contained but can be inter-urban, provincial, national and international in scope. Hence, many characteristics relevant to the role of governments cannot be meaningfully discussed from the limited spatial perspective of an urban region or a rural area. Second, air and water resources possess a unifying element lacking in the other resources: they are common carriers. This provides a unity for the wide variety of uses of each and of environmental problems found in each. This characteristic is clearly more dominant in the case of water than air, confined as it is to channels and basins. In both cases it may be somewhat deceptive, because air and water problems vary considerably from city to city and province to province. Still, the unity of these resources is the feature that stands out for purposes of this paper. It must be translated into a certain unity of administration which in turn must be reflected in governmental arrangements.

THE COMPETING USES OF AIR

The primary use of the air resource is to support life. Its most important element is oxygen, without which the plants and animals of the biosystem, including man, would perish. As a component of the hydrological cycle, it is the conveyor of fresh water to the earth's continents. The air resource also has many secondary uses. It is a transportation medium and communications channel. It is a necessary input, and sometimes a controlled constituent, of most production processes. Most important for this study, it is a receptacle for the waste residuals of all human activity.

Table 15

Emissions in Thousands of Tons Due to Fossil Fuels[a]
1966-1990

Source	Aldehydes	Carbon Monoxide	Hydro-Carbons	Other Organics	Oxides of Nitrogen	Oxides of Sulphur	Parti-culates	Total Without CO_2	Carbon Dioxide	Total With CO_2
Residential & Commercial	5.3	75.3	20.6	–	140.2	973.9	182.6	1,397.9	82,664.9	84,062.8
Industrial	2.6	351.7	72.2	.7	166.2	1,029.0	723.9	2,346.3	68,725.0	71,071.3
Transportation	16.9	8,460.5	1,598.8	25.3	457.1	199.8	88.7	10,847.1	71,702.9	82,550.0
Electricity Generation	.1	1.7	1.2	.1	104.5	332.6	395.6[b]	835.8	20,790.0	21,625.8
Totals	24.9	8,889.2	1,692.8	26.1	868.0	2,535.3	1,390.8	15,427.1	243,882.8	259,390.9
Percentage Total Without CO_2	1.6	57.8	11.0	1.7	5.6	16.6	9.0			
					1975					
Residential & Commercial	5.9	32.0	12.6	–	159.0	989.9	101.3	1,300.7	100,999.2	102,299.9
Industrial	3.9	332.8	69.2	1.4	231.5	1,154.1	696.9	2,489.8	98,393.6	100,883.4
Transportation	25.2	12,446.0	2,352.6	37.2	683.7	346.9	134.5	16,025.9	109,293.5	125,319.4
Electricity Generation	.2	4.8	2.9	.1	267.4	803.5	1,162.5[b]	2,241.4	49,320.0	51,561.4
Totals	35.2	12,815.6	2,437.3	38.7	1,341.6	3,294.4	2,095.2	22,057.8	358,006.3	380,064.1
					1990					
Residential & Commercial	7.1	7.3	8.8	–	205.7	1,122.8	62.3	1,414.0	142,888.2	144,302.2
Industrial	7.2	377.5	80.2	3.0	400.9	1,650.1	812.9	3,331.8	173,392.3	176,724.1
Transportation	45.1	20,853.8	3,961.4	65.7	1,237.4	922.4	259.8	27,345.6	208,930.9	236,276.5
Electricity Generation	.6	11.2	8.0	.4	710.5	1,403.5	3,195.0[b]	5,329.2	127,500.0	132,829.2
Totals	60.0	21,249.8	4,058.4	69.1	2,554.5	5,098.8	4,330.0	37,420.6	652,711.4	690,132.0

[a]Based on estimates and projections prepared by the staff of the National Energy Board, Ottawa, May, 1970.

[b]Most of these particulates could be removed by precipators.

Incredible as it appears to many Canadians over 25 years of age, there is a growing conflict between the primary and the many secondary uses of air. The world's atmosphere is an immense reservoir girdling the globe. Until a short time ago, one or two decades at the most, the assimilative and restorative capacity of this reservoir was thought to be limitless. In recent years, this comforting notion has given ways to the realization that the atmosphere, while immense, is finite. Expanding population, industry and technology are generating more and more pressures on this resource. The capability of the atmosphere to satisfy all demands upon it is being exceeded, globally, nationally and especially locally within urban regions. Under various circumstances, the side effects may be harmless, debilitating or lethal. The primary use of air – to support life – is being compromised by its secondary uses.

SOURCES AND AMOUNTS OF AIR POLLUTION

The dominant source of air pollution is the combustion of fossil-fuels, principally coal, petroleum products and natural gas. It is useful to subdivide fossil-fuel consumption into four components: residential and commercial, industrial, transportation, and electric power generation. Out of the total Canadian consumption of 130.5 million tons (coal equivalent) in 1966, 35 per cent was consumed by the nation's homes and offices, 28 per cent by industry, 29 per cent by transportation facilities, and 8 per cent by electric power generation. The recent report of the National Energy Board projects that the total demand for fossil-fuels could more than double over the next 20 years, rising to 337.5 million tons of coal equivalent.[1] During this period, the transportation component is projected to grow to 31 per cent of the total and electrical power generation to 19 per cent. Industrial consumption is expected to remain at 28 per cent and residential and commercial use is projected to drop to 22 per cent. Rough estimates of the amounts of the various primary by-products of combustion are displayed in Table 15.

Air pollutants are often divided into two categories on the basis of their chemical stability. The first category includes substances that do not react with other substances and are not changed in the air. Among the primary by-products of combustion are water, carbon dioxide and the solid particulates seen as smoke, dust and bits of metal. Since fossil-fuels are composed largely of carbon and hydrogen, water and carbon dioxide are major by-product of their combustion. The formation of water presents no direct threat to the quality of the environment. Carbon dioxide is another matter, however. It is by far the largest by-product of combustion. It constituted 94 per cent, or 244 million tons, of Canadian combustion products in 1966 and its annual production could triple by the year 2000. Although it is a safe, chemically stable gas, there is growing concern by scientists

[1] National Energy Board, *Energy Supply and Demand in Canada and Export Demand for Canadian Energy 1966-1990* (Ottawa, Queen's Printer, 1969), p. 5. Conversion to tons of coal equivalent prepared by N.E.B. staff.

about the increasing concentration of carbon dioxide in the earth's atmosphere. This was discussed in Parts One and Two.

Particulate matter, the other stable by-product of combustion, is most obvious to the naked eye. Commonly referred to as dustfall, it includes solid particles of ash, carbon, oil and tiny bits of metal and metal oxides. If one excludes carbon dioxide, particulates constituted nine per cent of total emissions, or 1.4 million tons, in 1966. The projections in Table 15 suggest that its annual production could more than triple by 1990. Emissions of particulate matter from electric power stations could grow nearly eightfold in the next 20 years.[2]

The second category of air pollutants is composed of invisible, chemically active substances. They are harder to detect, more intractable and much more immediately dangerous to human health than are air pollutants in the first category. Carbon monoxide is the major component by weight in this category. It constituted 58 per cent of the total by-products of combustion, excluding carbon dioxide, or nearly nine million tons in 1966. Sulphur oxides were estimated to comprise 16.6 per cent, hydrocarbons eleven per cent and nitrous oxides six per cent. Transportation accounted for 90 per cent of the carbon monoxide and other hydrocarbons in 1966 and nearly half of the nitrous oxides. Power generation, industrial burning and space heating supplied most of the sulphur oxides. These proportions are projected to remain essentially unchanged over the next 20 years except that power generation is expected to contribute an increasing percentage of sulphur oxides.

The chemically active by-products of combustion are fairly limited in number. Combined with heat and light, however, they undergo complicated and only partially-known chemical reactions in the atmosphere. The by-products of these reactions are much more numerous, difficult to identify and trace, and extremely dangerous. The most striking example of secondary pollution is the smog that hangs over Montreal, Toronto, Vancouver and other major cities. It derives from products formed when hydrocarbons and nitrous oxides react in the presence of sunlight. More secondary by-products are being identified all the time and it is clear that this form of pollution has been increasing rapidly, if surreptitiously. No systematic data have been collected over a period of time, however, so the exact nature and extent of this pollution is unknown.

Although fossil-fuel combustion is the dominant source of air pollution, it is not the only source. An exceedingly varied and constantly expanding list of substances is continually being added to the air we breathe. Examples include fuel additives such as lead, chemicals used in industrial processes, the fertilizers, biocides and pharmaceuticals used by the agriculture and forestry industries and, of course, radioactive elements from nuclear tests and power stations.

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[2] It is also of interest to note that the technology now exists to greatly reduce, if not eliminate, particulate emissions from furnace stacks.

EFFECTS AND COSTS OF AIR POLLUTION

Air pollution affects many things – health, vegetation, wildlife, fisheries, corrosion of structures and materials. Its costs, therefore, take many forms – health, social, ecological and economic. This is not the place for a detailed exposition of the multitude of ways in which air pollution can affect man and his environment. A brief summary would be of interest, however, and is necessary to indicate the present and possible future dimensions of the problem.

Air pollution is heavily implicated as a factor in a wide range of human illnesses and this clearly represents its most serious direct cost.[3] The effects of air pollution on people vary greatly depending on factors such as concentration, duration of exposure, differences in age and health and the synergistic or cumulative effect associated with simultaneous or sequential exposure to more than one pollutant. The direct effects may range in severity from the lethal to the merely annoying. Nitrous oxides combine with other chemicals to form ozone and other oxidants in smog which cause eye irritation and are injurious to plants. Sulphur dioxide and sulphur trioxide combine with water to form sulphurous and sulphuric acid. Condensed on particulate matter, they can be inhaled into the lungs, exacerbating if not causing a variety of pulmonary diseases including emphysema, tuberculosis, pneumonia, bronchitis, asthma, and even the common cold. There is statistical evidence that air pollution has contributed significantly to the incidence of cancer.[4] Carbon monoxide is perhaps the most serious of the invisible, toxic pollutants. It reduces the blood's capacity to carry oxygen through the body and even very low levels can contribute to headache, confusion and dizziness. Exposure to higher concentration can damage the eyes, ears and brain.[5]

Air pollution can be fatal. Disasters resulting from atmospheric inversions that held pollutants close to the ground have been recorded in several areas since the turn of the century. The inversions in the Meuse Valley, Belgium in 1930,

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[3] O.C. Herfindahl and A.V. Kneese, *Quality of the Environment* (Baltimore, The Johns Hopkins Press, 1965, printed for Resources for the Future, Inc., Washington), p. 29:

> The . . . evidence on links between air pollution and health has been summarized by a former surgeon-general of the U.S. Public Health Service in part as follows:
>
> a) Comparison of morbidity and mortality statistics with indices of air pollution suggests that communities with the heaviest air pollution loads tend to rank high in death rates from a number of diseases.
>
> b) There is a significant correlation between air pollution and cancer of the esophagus and stomach, lung cancer, and arterial sclerotic disease.

[4] See Donald O. Anderson, "Effects of Air Contamination on Heath", in *Background Papers: Pollution and Our Environment Conference,* I, A3-2 (Montreal, Canadian Council of Resource Ministers, 1966).

[5] Last September the Montreal Health Department released a report on air pollution in that city which indicated that levels of carbon monoxide had been high enough on occasion at certain locations to cause eye, ear and brain damage in some persons. See *La pollution de l'air par le monoxyde de carbone à Montréal,* Rapport du service de Santé de Montréal (mars, 1969), p. 64.

Donora, Pennsylvania in 1948, London, England in 1952 and New York City in 1966 resulted in hundreds of deaths from aggravated bronchitis, pneumonia and heart disease and accelerated thousands of others, particularly in the older age groups.[6]

The menace of air pollution to human health, carries huge and growing costs in suffering, in medical bills and in welfare compensation. Direct effects on humans also have parallels in the animal world. Effects on pets and on animals of economic importance almost certainly exist, although they have hardly been documented at all.

Biochemical effects of an urban-wide scale have been documented. Cities receive 15 to 20 per cent less total solar radiation than their rural surroundings,[7] and they experience 100 per cent more winter fog and 30 per cent more summer fog. This has a wide range of side effects from biological and psychological reactions to higher accident rates. These side effects translate into an equally wide range of costs.

Air pollution also causes immense damage to property each year. The most potent agents are sulphur and various oxidants. Sulphurous and sulphuric acids corrode metal and react very strongly with limestone or marble. Sulphur oxides cause discoloration, hardening, and embrittlement of rubber and other materials. The most noticeable of all forms of property damage, of course, is soot, which settles over wide areas discoloring and dirtying the landscape, buildings and clothing. These effects mean not only a shorter useful life for machinery, buildings and personal property, but also higher annual maintenance costs for cleaning, repairing, painting and replacement. Estimates of incremental annual property costs due to air pollution are staggering, but they range widely because of the difficulties of measurement.

The geographical extent of the effects of air pollution is an important indicator of the potential magnitude of its costs. As has been noted on several occasions in this study, the atmosphere provides a vehicle for the widespread transportation of pollutants to remote areas of the world.[8] The effects on plant and

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[6] Less dramatic episodes have been reported in Glasgow, Manchester, Detroit and Osaka. See Frank E. Speizer, "An Epidemiological Appraisal of the Effects of Ambient Air on Health: Particulates and Oxides of Sulphur", *Journal of the Air Pollution Control Association,* XIX (Sept., 1969), p. 647. See also the *Clean Air Yearbook 1968-69* (London, England), p. 13.

[7] John M. Pierrard, "Environmental Appraisal – Particulate Matter, Oxides of Sulphur and Sulphuric Acid," *Journal of the Air Pollution Control Association,* XIX (Sept., 1969), p. 634: "Only in exceptional cases can this diminution be ascribed to causes other than scattering by particles".

[8] The geographical range of any pollutant depends upon density and other properties. It depends upon the height and other characteristics of the source, whether it be a campfire, a furnace stack, or a jet transport. It depends on the topography of the landscape and on the vagaries of meteorological conditions. Within these many constraints, the range of some pollutants may extend from a few feet to thousands of miles.

animal life, on air, soil and water resources and, to some extent, on human health and property are similarly world-wide in scope.[9]

Because of the availability of evidence, sulphur dioxide provides an excellent example of this phenomena. When sulphur dioxide is emitted, it may linger many hours or days in the air, but eventually it reaches the ground in some form. The figure in Appendix 5 shows the configuration of oxides of sulphur during 1969 within Metro Toronto. The intensity varies significantly from the core to the fringe. In the Sudbury district the effects of sulphur dispersion have been measured well beyond the urban region but within the province. Sulphur dioxide emitted by Sudbury's three smelters has stunted some vegetation within a 720-square-mile area and severe tree damage has been detected up to 30 miles from the smelters.[10] Depending on topographical, meteorological and other conditions, the oxides of sulphur, nitrogen and other pollutants, and their many by-products, may be carried much greater distances. Swedish and Norwegian scientists, for example, have found that the soil of Scandinavia has become significantly more acidic within the past 10 years. They attribute this directly to the fall-out in rain and snow of sulphur dioxide from industries and thermal-electric plants in Europe and Britain. The long-term ecological implications of this are unknown but clearly are a cause for concern.[11]

Canadian experience both pre-dates this and confirms the persistence of oxides of sulphur in the atmosphere:

> In 1929 complaints of damage to agricultural crops and forests in northern Stevens County, State of Washington, from sulphur dioxide discharged from a large base-metal smelter at Trail, B.C. were referred

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[9] The effects of radioactive fall-out on human health illustrate the point. Concern over this led to an international convention in 1960 banning nuclear tests in the atmosphere. Global dispersion of carbon dioxide and particulate matter was discussed in Parts One and Two, and evidence of worldwide effects of biocides was mentioned in Part Four.

[10] From a paper by Dr. Samuel Linzon, chief of the phytotoxicology section, Air Management Branch, Ontario Department of Energy and Resources Management, delivered to the 63rd Annual Meeting of the Air Pollution Control Association, St. Louis, Missouri, June, 1970. Over a 10 year period (1953-63) the loss in the production of white pine in the 720-square-mile area mentioned amounted to $1,171,000.

[11] Dr. Brynjulf Ottar, Director of the Norwegian Institute for Air Research, recently expressed his concern about rising acidity in Scandinavian rain and snow, attributed to sulphur emissions in Britain and West Germany. This problem was highlighted in the winter of 1969 when grayish snow with black spots fell on eastern Norway and western Sweden. Dr. Ottar and his colleagues assume that the blackness was caused by pollutants with a high sulphuric acid content resulting from combustion processes in central Europe. They hypothesize that air currents carried the pollutants in a counter-clock-wise direction to the east and then over Sweden and Norway. Such air currents, as well as the prevailing southwesterly winds from England, have increased the acidity of precipitation in Norway with detrimental effects on its soil and water. Dr. Ottar stated that, "We look upon continental pollution as a greater problem than local pollution." *Globe and Mail,* Jan. 15, 1970, as confirmed by telegram, July 7, 1970.

> to the International Joint Commission (U.S. and Canada) for investigation and settlement. This smelter is situated in the relatively narrow Columbia River valley, about ten miles north of the international boundary. The valley is flanked by mountain ranges which rise on both sides of the valley to heights of several thousand feet. This natural channel served to confine the smelter gases to the main Columbia River valley and its tributary valleys for many miles. An award of $350,000 for damages was made to U.S. residents by the International Joint Commission in 1931.[12]

Ultimately developments were introduced which enabled the smelter to recover more than 90 per cent of its former atmospheric wastes as useful by-products.[13]

SOME RELEVANT CHARACTERISTICS OF AIR POLLUTION

In light of the above it is possible to identify a number of characteristics of significance to the role of governments. Six stand out and will be discussed: air as a public good, concentration of air pollution in urban regions, atmospheric dispersion, externality of sources, resource interdependence, and exponential rate of growth.

Clean air is a public good. Indeed no other resource exhibits the same degree of "publicness". Land can be parceled and fenced. Water can be bottled. Scenery can be hidden. One can even isolate oneself to some extent from noise. But man has no choice but to breathe the air around him – polluted or not. The same is true of all animal and plant life. Although clean air carries a zero price, it is not a free good. It carries a zero price because there is no way to contain it. The cost of maintaining the quality of the atmosphere at the level required to support the biosystem is a present and growing burden on the public and private sectors. The continued indiscriminate use of the atmosphere as a sink for the waste residuals of combustion and other processes is increasingly incompatible with its primary use – to support life.

Air pollution is concentrated in urban regions. They experience the greatest immediate side effects and bear the heaviest direct costs. In Part Three the process of urbanization was discussed and projections were displayed for urban growth, population, housing, transportation, industrialization and utilities. All of the projections indicated both a continuing concentration of these components in fewer centres and enormous growth of these centres over the next 30 years. These projections can be generally related to those for emissions from fossil-fuel combustion set out in Table 15, and together they suggest the enormous dimensions of the air pollution problem faced by Canadian cities.

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[12] Morris Katz, "Regional Air Pollution Control", in *Background Papers: Pollution and Our Environment Conference*, II, B 17-2-2 (Montreal, Canadian Council of Resource Ministers, 1966), p. 2.

[13] *Ibid.*, p. 3.

Perhaps one example would help to clarify the implications of concentration. It relates to vehicle ownership and carbon monoxide production. Table 6 provides projections of motor vehicle ownership in Canada. The projections indicate that Canadians will be driving around seven million private vehicles by 1970.

> Carbon monoxide is produced by . . . vehicles . . . without smog-control devices, at the rate of one pound (equivalent to 7.5 cubic feet of gas) for each two pounds of fuel burned. Assuming the lethal concentration of carbon monoxide is somewhere in the range of 200 parts per million or 0.02 per cent, and assuming each automobile in a city drives 10,000 miles per year and obtains 14.7 miles per gallon – the national average figures – each car will produce roughly about 2,500 pounds of carbon monoxide in a year, while trucks produce considerably more.[14]

This adds up to a Canadian national total in the neighborhood of eight million tons, not incompatible with the data in Table 15.

> If we further assume an urban population density of 10,000 per square mile with one car or truck for every two persons, a little arithmetic indicates that such a community produces enough carbon monoxide each year to poison *the entire atmosphere above itself*. . . . Fortunately, due to natural processes, the half-life of carbon monoxide in the atmosphere is apparently fairly short, but peak concentrations as high as 140 parts per million have been observed over city streets during periods of heavy traffic.[15]

This example also serves to illustrate the importance of the third characteristic, atmospheric dispersion. Without it man would not be able to co-exist with his machines and enjoy the benefits of an urbanized, industrialized society. Because of it, air pollution is of concern to all orders and levels of government and to the international community, since no government can control directly the sources and effects of pollution originating outside its boundaries.

Transboundary movements of air pollution can be expected to increase both in their number and intensity in the years ahead. The dimensions and side effects of this could be especially significant to Canada in three areas – the St. Lawrence, the Maritimes and the Lower Fraser Valley. Part Three discussed the projected population increase of urban regions on both the Canadian and the United States sides of these areas. The projected 30 year population increment of American cities adjacent to Ontario, Quebec and the Maritimes was three times that projected for Canada as a whole. Similarly, the projected population increment in the Seattle-Tacoma-Portland complex, which shares a common geographical basin with Vancouver, was equal to the total projected population of Vancouver in the year

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[14] R.W. Ayres, "Air Pollution in Cities", *Natural Resources Journal,* IX (January, 1969), p. 5.
[15] *Ibid.*

2000. Projected increments of industrial growth, electrical energy requirements, and fossil-fuel combustion required to sustain this population are not available, but they would no doubt be similarly huge, dwarfing that on the Canadian side of the boundary in these areas. The consequences of this for transboundary movements of air pollutants can be inferred from Figure 9. It shows the dominant direction of air flows across the international and other political boundaries for January, April, July and October. The figure illustrates two points of crucial significance to future environmental management of air resources. First, the pollution content of air systems, in common with their temperature, moisture content and other characteristics, can be interpreted intelligently only on a continental basis. Second, southern Ontario, and less markedly, the Maritimes, stand out as the major zones of convergence for the air systems of North America.

This relates directly to the fourth characteristic, the externality of the sources of air pollution. This has two aspects. First, as demonstrated above, a significant proportion of the pollution content of, and the potential fall-out from, the atmosphere over Canada's most populous areas originates outside of Canada. In the case of Quebec and the Maritimes some of the pollutants and fall-out may originate inside Canada but outside those provinces. Second, a high proportion of the pollution-intensive fuels, biocides, transportation vehicles, industrial furnaces and other machines used in Canada are imported. They are imported in many forms of raw products or of designs licensed for manufacture in Canada. Either way, they are the products of externally-based and externally-controlled technology. The implications of this were discussed in a much broader context than air pollution in Part Two.

The fifth characteristic is the rapid rate of growth in the variety of air pollutants. This stems from two factors. First, world-wide industrialization, based on a dynamic, market-dominated technology, is injecting an ever-increasing range of chemicals into the atmosphere. Second, in combination with light, atmospheric moisture and other factors, these chemicals are breeding a second order of by-products of largely unknown effects. Identification and assessment is difficult because of the properties of these by-products, such as short life or low concentration. Research is gradually uncovering evidence, however, that demonstrates cause and effect relationships at lower and lower levels of pollution and at varying degrees of exposure by humans, animals and plants.

Examples of the last characteristic, resource interdependence, have been cited throughout the study. In many instances, there is a strong interrelationship between air, soil and water pollution. The process is exceedingly complex but may be generally viewed as a relatively simple cycle. The by-products of fossil-fuel combustion are emitted into the atmosphere, or wind may pick up minute soil particles coated with fertilizers or biocides. They may be carried great distances and to great heights, depending on their density and on topographical and meteorological conditions. They may be dissolved by moisture as it moves through the atmosphere or they may become attached to rain droplets as they fall to the

surface. On reaching the earth's surface, the contaminated rain or snow pollutes the soil or finds its way into rivers and lakes.

While the overall process is readily grasped, its extent is not generally realized. An address given by Dr. Barry Commoner which was summarized in an editorial of the *New Scientist,* cited an example which illustrates the extent of these interrelationships. It also illustrates that environmental degradation is not due to minor and easily correctable faults in technology but to our very success in achieving our stated technological aims. He stated that Detroit's attempts to grapple with the problem of auto exhausts by installing ingenious waste-fuel devices, are unlikely to do more than slightly alter it. By reducing the amount of unburned fuel, the level of nitrogen oxides in the air will be increased, since less will be able to react with the hydrocarbons in the exhaust. In the atmosphere, some will combine with waste hydrocarbon from non-automobile sources and make more smog, and the rest will be precipitated in rain and snow as nitrates. In other words, if cars are stopped from producing smog by that means, they become fertilizer plants. He went on to refer to calculations which show that while seven to eight million tons of nitrogen in the form of inorganic fertilizer are put on American farms each year, another three million are produced from car exhausts. Figures from New England show that the nitrate content of rainfall is directly proportional to local use of gasoline.[16]

Because of resource interdependence, it is often necessary to apply the various management strategies – research, planning, incentives, regulation, etc. – to entire systems in order to effect solutions. These systems may be spatially as small as the air, land and water resources of the Okanagan or Qu'Appelle basins, or they may be as large and jurisdictionally complex as the Great Lakes. Unless this fact of resource interdependence is respected, the most earnest attempts to resolve an environmental problem by a single-source or single-resource approach may be doomed to failure.

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[16] Editorial "Environmental Soup", in *New Scientist,* XLIII (Aug. 7, 1969), p. 267. The *New Scientist* further summarized Commoner:

> The modern high-compression internal combustion engine causes smog and nitrate fall-out *because* it is technologically successful. The modern sewage-treatment plant, causes algal overgrowths and river pollution *because* it produces, as it is designed to produce, inorganic nitrate and phosphate. Modern farm fertilizers cause eutrophication *because* they succeed in raising the level of free nutrients in the soil. "Our pollution of the environment is the direct consequence, not the accidental result, of our massive technological effort."

Commoner further argues that no one would design a machine that failed to respect the laws of thermodynamics. Yet many machines ignore the law of ecology.

FIGURE 9

MEAN AIRFLOW AND MASS CONVERGENCE OVER NORTH AMERICA

MAPS TAKEN FROM R.A. BRYSON "AIR MASSES, STREAMLINES AND THE BOREAL FOREST" GEOGRAPHICAL BULLETIN, 8, 3, 1966

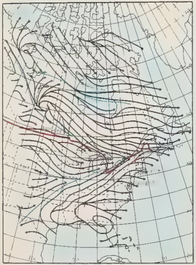

FIGURE 22 Streamlines of the Surface Resultant Wind in January

JANUARY

This illustrates the critical position of southern Ontario and Eastern Canada very clearly. In the mean condition air from the southern U.S. converges with western air and with air from arctic areas along a confluence line which coincides with the international border between Windsor and Quebec. This diagram represents the average of individual synoptic situations; on any individual day the dominant airflow over eastern Canada may come from any of these sources (or more rarely from other areas such as the Atlantic).

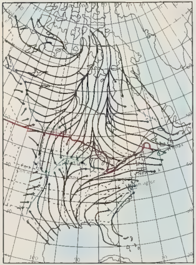

FIGURE 25 Streamlines of the Surface Resultant Wind in April

APRIL

Convergence in eastern Canada is much the same as in January except that Pacific air is "pinched out" so that the main convergence is between air of arctic or tropical origin. The convergence line again coincides with the international border.

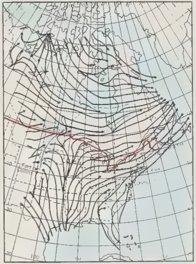

FIGURE 28 Streamlines of the Surface Resultant Wind in July

JULY

The Tropical airstream ... now extends into northern ... northern Quebec and Labrador. It must be noted however that this is the mean or resultant flow and other varieties of air ... are quite frequent in this eastern region."

From the pollution point of view it will be obvious that the dominant airflow in southern Canada from Saskatchewan eastwards has a trajectory from the U.S.A.

South of Hudson Bay the air on one third of the days in July is of "United States" origin.

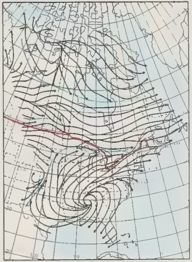

FIGURE ... Streamlines of the Surface Resultant Wind in October

OCTOBER

The winter January pattern begins to re-establish itself as the ... tropical convergence retreats southwards and eastwards. The populated areas of eastern Canada are in the main affected by ... the international border.

CANADA – U.S.A. BORDER

MAIN AREAS OF CONVERGENCE

Chapter XV

The Waters

Canada possesses one-quarter of the world's known volume of fresh water, 117,000 miles of oceanic coastline and a rich continental shelf, 40 per cent as large as Canada's entire land area.[17] Fresh water covers 291,000 square miles or 7.6 per cent of the country's surface.

These resources have had a profound influence in shaping the Canadian nation. From the days of the early voyageurs, waterfront sites have been the natural choice for towns, cities and industries. Rivers, lakes and coastlines offered easy access and cheap transportation. They provided priceless fisheries, water for agriculture, water for processing, water for power and water for waste disposal. In the early days of exploration and expansion, deterioration of water resources was avoided by the limited concentration of settlement and industry, the primitive power of technology, and the sheer abundance of supply.

Population growth, urbanization, industrialization, modern technology and the other trends discussed in earlier chapters, brought about a significant change. Inland and coastal waters were forced to accept increasing torrents of waste in outfalls from cities and factories, in run-off from farms and forests and in precipitation from the atmosphere. Yet, pioneer attitudes remained, viewing water as an abundant "free good" always at hand. There was little general awareness of the consequences of exceeding the assimilative capacity of our waters. With affluence, however, a new use gained in importance. From the sand beaches of P.E.I. to the island paradise of the Georgia Straits, our inland and coastal waters became a haven for increasing numbers of Canadians eager to participate in aquatic sports or simply to enjoy the wonders of nature. At the same time, the growing degradation of our waters became more evident. The causes and consequences have

[17] Canada's submerged continental margin, which includes the continental shelf and the continental slope beyond, is probably the largest in the world, comprising an area of 1.5 million square miles. Of this, about 500,000 square miles lie off the East Coast, 400,000 square miles lie in the Hudson Bay-Hudson Strait region, 50,000 square miles off the West Coast and 500,000 to 600,000 square miles in the Arctic Region. The continental sea, seabed and sub-sea resources are a potential source both of riches and pollution.

been explored by new sciences, natural and social, and exposed to the public by modern communications media. Canadians have become increasingly unwilling to accept the continuing degradation of their water (and other) resources. Knowing that the necessary planning, regulatory, research and other strategies were available, they have begun to insist that economic growth be made compatible with the maintenance of water quality.

The federal and provincial governments have sought to respond to this demand. They have found, however, that laws and institutions established under different circumstances often do not facilitate and sometimes actually frustrate solutions to the problems of water quality. Although federal and provincial water laws and institutions are being changed rapidly, the extent and potential effectiveness of these changes are frequently limited by a constitution that is silent on the subject of water quality management.[18] Few of the emerging issues have been decided by the courts and operating guidelines respecting the roles of the two orders of government must be deduced. The deductions by different governments and authorities, are sometimes in conflict. The resulting jurisdictional uncertainty breeds confusion and duplication in many areas while leaving others virtually unattended.[19] Moreover, deductions that necessarily flow from the British North America Act cannot possibly reflect certain characteristics of water that were not perceived in 1867 but that need to be respected in any functional division of responsibilities between federal and provincial governments.

SOME FUNDAMENTAL CHARACTERISTICS OF WATER RESOURCES

Six fundamental characteristics of inland and marine water resources warrant attention. Some of them may appear to be self-evident but they are crucially important. They imply certain characteristics of water management which, if recognized by governments in determining their appropriate roles, would greatly facilitate a resolution of major, emerging water quality problems.

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[18] See Dale Gibson, *Constitutional Jurisdiction over Environmental Management in Canada* (Unpublished, 1970).

[19] See Dale Gibson, "The Constitutional Context of Canadian Water Planning" (Paper A3-1 in Background Papers, Water Workshop Seminar, Canadian Council of Resource Ministers, unpublished, 1968), p. 2:

> A newcomer to Canadian fresh water management encounters a bewilderingly complex administrative galaxy. Boards and agencies without number, some in splendid solitude and others attended by many satellites, orbit endlessly without apparent heed for the others. Great unaccountable voids are occasionally to be seen, and the basic organizing pattern, if one exists, is difficult to discern.
>
> Much of the blame for this complexity has been laid on the Canadian constitution. To a large extent, this is justified. The subject of water resource management straddles the two groups of constitutional powers – federal and provincial – created by the British North America Act, and a study of these powers can explain many features of the present administrative structure. It would be wrong, however, to assume that all the confusion and inefficiency that marks the existing structure is inevitable unless the constitution is amended.

First, the management of water in Canada is almost entirely in public hands. This is wholly true of our coastal and oceanic water resources and virtually true of our fresh water resources.[20]

Second, water is contained. Surface water is contained in natural channels – brooks, streams, rivers and estuaries. Much of it is held in basins – lakes, bays, seas and oceans. Underground water is confined by reservoirs called aquifers, some in the form of basins, others like buried rivers.

Third, water is dynamic. It flows from one area to another in constant motion. An incredibly complex network of brooks, streams and rivers drains the entire continent, pulled by gravity down natural gradients through lakes and into estuaries, bays and finally, the oceans. Underground waters also move, slowly but surely, draining into springs or rivers or finding some other outlet to the sea. The oceans, too, are in constant movement, with surface and subsurface currents driven by tremendous forces. And all of this is interconnected in a great hydrological cycle, the atmosphere replenishing the land with precipitation, the land discharging the water back into the ocean.

Fourth, water is used for an almost infinite variety of purposes. It is the universal resource, the medium in which all life began. It is the major constituent of the human body, a vital component of the air we breathe, the principal feature of our weather and the habitat for all aquatic life forms, including the minute phytoplankton that generate 70 per cent of the world's oxygen supply. It is an essential ingredient of most economic and social activity. Our fresh-water rivers and lakes and our salt-water estuaries and oceans are used for fishing, for navigation, for recreation, for power generation – and for the disposal of wastes. Our oceans are a vast depot of mineral and other resources. Our fresh waters are essential for domestic use, for thousands of industrial processes, and for irrigation.

Not all of these uses are compatible. Indeed, the fifth and, in many respects, most important characteristic of water is the interdependence of its uses within any given watershed, basin or aquifer. This interdependence is much stronger for water

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[20] Canadian Committee for the International Conference on Water for Peace, "Water Resource Development in Canada: A Perspective," in *Canadian Papers: International Conference on Water for Peace* (Ottawa, Department of Energy, Mines and Resources, 1967), p. 7.
With regard to fresh waters:

> Canadian courts have declared that there are no private proprietary rights in water flowing in a defined channel, and that riparian owners are entitled to access and reasonable use, subject to certain public rights of navigation, fishing and log-driving. In British Columbia and in the Prairie provinces, riparian rights have been greatly modified through systems of water licensing and priority of uses. In the province of Quebec, there is a presumption of ownership of the riverbed to the mid-point of the stream on non-navigable and non-floatable waters. All deeds before 1884 included such rights, which often vested ownership of power sites and Atlantic salmon fishing pools in private individuals. Since that date, however, the Quebec government has reserved a strip of land along the water's edge of such rivers. In other provinces, water law is generally based on English common law.

than for air or for any of the other resources. In the case of fresh surface water, the use of a river for one purpose has a clear effect on its uses for other purposes. The implications of this for management are reinforced in Canada, where many populated watersheds are large and a single river is often called upon to fulfill many different uses on its journey to the sea.[21] Most uses, including waste disposal, are necessary, but they are often difficult to reconcile. Each river is unique in that each has a different mix of uses and different flow characteristics. Each use therefore requires different quality standards and different controls of flow volumes. Although interdependence is most striking in the case of flowing rivers, it is also a strong characteristic of lakes, bays and estuaries and, indeed, of seas and entire oceans. In the case of underground waters, interdependence is frequently the dominant characteristic. Use of an aquifer for drinking and other withdrawal purposes often precludes altogether its use for waste disposal. Extensive measures are sometimes required to ensure that waste from holding tanks and lagoons does not seep into underground aquifers.

Another universal characteristic of water is that it respects no man-made boundaries. Streams flow from one political jurisdiction into another, rivers and lakes are shared by various jurisdictions, underground aquifers straddle political boundaries, and ocean currents lap the shores of many countries. Some of Canada's major rivers are contained within a single province or within the northern territories, but most are not; political boundaries have been established largely without regard to the geography of water resources. Because of this fact, water resources can be divided into various jurisdictional categories. Several stand out: international waters, interprovincial waters, boundary waters, provincial waters, territorial waters and federal waters. Because of the interdependence of waters, it is convenient to add a seventh category, interjurisdictional waters. The interjurisdictional character of certain waters stems from three aspects of interdependence. First, the physical interconnectedness of water systems means that the management of waters in any of the foregoing categories, including those situated wholly within a single jurisdiction, may significantly affect the quality of waters outside that jurisdiction. Second, even waters situated wholly within a province or territory, may sustain fish or waterfowl whose life cycle depends upon the adequacy of water management both in Canada and in other countries. Third, such

[21] The Saskatchewan-Nelson system, as it drains the prairies, provides a habitat for aquatic life, waterfowl, fur-bearing and other animals; it generates electric power, irrigates arid lands, supports all types of recreation, supplies drinking water to all of the principal cities except Winnipeg, and carries most of the human, industrial and agricultural wastes of the three provinces.

waters may be used for an activity, such as navigation, whose effects on the quality of the water resource may require action at the national or international level.[22]

A number of water management principles may be deduced from these fundamental characteristics of the resource. Before considering them, however, it is useful to take a brief look at the varieties, sources and volumes of water pollution, their effects and costs, and the major water quality problem areas. This should facilitate the subsequent consideration of water management principles and other characteristics relevant to the role of governments.

VARIETIES, SOURCES AND VOLUMES OF WATER POLLUTION

Water pollutants may be grouped in a number of different ways. They may be grouped according to their sources or their effects, but for purposes of this study, it is most convenient to group them under three broad categories – degradable, non-degradable and persistent. Pollutants in each of these categories exhibit different characteristics and produce somewhat different effects.

The classification, degradable pollutants, stems from the process of degradation that takes place when organic wastes are released into a water body. The waste is attacked by bacteria and other organisms and broken down into its organic components, mainly nitrogen, phosphorus and carbon, which provide nourishment

[22]It may be helpful to define these categories more completely. *International waters* means surface waters that flow across the international boundary between the U.S. and Canada. *Interprovincial waters* means surface waters that flow across the boundary between one province and another or between a province and a northern territory. *Boundary waters* means the surface or underground waters over which passes the boundary between the U.S. and Canada, the boundary between two Canadian provinces, or the boundary between a province and a northern territory. In the case of surface waters, this includes all bays, arms and inlets but does not include tributary waters which in their natural channels would flow into boundary lakes, rivers and waterways; nor does it include waters flowing from such lakes, rivers and waterways or the waters of rivers flowing across the boundary. *Provincial waters* and *territorial waters* mean waters wholly situated within the boundaries of a province or the northern territories, as the case may be. Territorial waters may also be referred to as *federal waters* since they fall under the exclusive jurisdiction of the Parliament of Canada. The latter designation would also include waters on federally-owned land within the provinces, as well as marine waters outside of the boundaries of any province.

for aquatic plants. In the process, oxygen is consumed.[23] Degradable pollutants include not only human, animal and plant wastes but also a wide range of household cleaning agents, agricultural fertilizers, industrial chemicals and refuse. The most widespread primary source of degradable wastes is domestic sewage but, in terms of volume, industry and agriculture produce significantly greater amounts. Most of the industrial component is generated by the food processing, pulp and paper and chemical industries. A single chemical or pulp and paper mill, for example, can produce an organic waste load equivalent to the sewage discharge from a large city.

Many pollutants are non-degradable. They are not broken down into their component parts by aquatic organisms after they enter a water body. They undergo no great change at all. The receiving body cannot purify itself of them; it can only dilute them. Non-degradable pollutants include a wide range of inorganic substances. They include the dust and sand washed off urban streets and the soil eroded from farm fields and denuded forest land. They include the common salts spread on streets and highways, and they include the salts of many heavy metals. The most widespread primary sources of non-degradable pollutants are domestic and storm sewer discharges from municipalities, agricultural run-off and, in some areas, drainage of metallic salts and acids from surface and subsurface mines.

The persistent pollutants include substances which do not fit easily into either of the above categories. They are called persistent because their complex chemical structure resists attack by aquatic organisms or by chemical treatment processes. Organic materials of this class degrade very slowly and may remain in an aquifer, lake or bay for very long periods. Or they may travel great distances, carried by rivers and by lake and ocean currents and by aquatic life. The same is true of inorganic materials, except that they don't degrade at all.

Although this group is of most recent origin, it contains the largest and most rapidly growing variety of substances. It includes the exotic synthetics produced

[23] Depending on the condition of the water body, this process may occur in one of two ways, referred to as "aerobic degradation" and "anaerobic degradation". Under aerobic conditions, stream bacteria and other organisms feed on the organic wastes and break them down into their organic components. This process consumes some of the oxygen dissolved in the water body. The oxygen level will drop at the point of waste discharge and then rise again. The extent and duration of the drop depends on a number of factors including the nature of the waste load, the temperature of the water body and the rate and volume of its flow. Under healthy conditions, the oxygen consumed is quickly replenished either by natural aeration or by photosynthesis carried on by aquatic plants. If the waste load becomes too heavy, however, all of the oxygen may be consumed. The conditions in the water body become anaerobic. The wastes continue to be broken down, but the agents of degradation change from bacteria that use free oxygen to organisms that use oxygen bound chemically to organic and inorganic compounds, mainly nitrates and sulphates. These same processes, greatly speeded up, are employed by sewage lagoons and by sewage treatment plants to break down organic wastes. Modern lagoon and plant systems are capable of reducing the oxygen load on the receiving water body by up to 90 percent. *As with natural processes, however, the resulting effluent is made up largely of plant nutrients.*

in profusion by the chemical industry. It includes most pesticides and herbicides, including the well-known organo-chlorides such as DDT, the organo-mercurides such as Panogen, and more recently, a new group of polychlorinated biphenols such as Aroclors. The group also includes petroleum and the many products resulting from the distillation of petroleum, such as phenols. And it includes long-lived radioactive products produced by the nuclear power industry and used in various industrial and research processes. The most fertile primary sources of persistent pollutants are the petro-chemical, agro-chemical and atomic industries. The petroleum industry, with its off-shore drilling and tanker transportation activities, also ranks very high.

In this discussion reference has been made only to the primary sources of the three categories of pollutants. The secondary sources are equally significant. They include all of the economic and social activities in which these products are employed, in industries, on the farm and in the home.[24] A great deal has been said in earlier parts of this paper about the increasing volume and growing variety of pollutants from each of the primary and secondary sources. Part Three discussed the rapid pace and concentration of urban growth in Canada. It examined the huge prospective increase in the volume of pollutants discharged by urban regions into our water bodies. It showed how these pollutants are inextricably linked with and emanate from domestic, commercial, industrial, power, irrigation, navigation and other urban uses of water and how urban waters therefore contain practically the entire range of possible water pollutants. Part Four discussed the potential growth of agriculture and forestry, surface and subsurface mining, transportation and recreation, and indicated how run-off from farms and forests, mines and transportation facilities could greatly increase pressure on our water resources. The last chapter described how even the fall-out of various air pollutants was an increasingly significant source of water pollution.[25]

EFFECTS OF WATER POLLUTION

The effects of water pollution are diverse and pervasive. Each of the pollutants in each of the three categories affects different water bodies in different ways, depending upon a multitude of natural, social and economic factors that are unique to each location. Because of this variability of effects, and because of the rapid rate of growth in the number of water pollutants, and because of the shortage of specialists, knowledge concerning the effects of water pollution lags far behind the phenomenon itself. Fortunately, however, a

[24] A good example of the extent and pervasiveness of secondary uses is seen in the group of polychlorinated biphenols. They are used in the manufacture of many industrial products as lubricants, in heat transfer processes, in paints, in synthetic resins and in waxes. They get into water via industrial effluents and also via atmospheric fall-out.

[25] The reader may wish to refer to the projections of urban growth in Tables 4 and 5, and the projections of industrial growth in Table 9 and Figure 8.

substantial body of knowledge has been built up over the years, and it is possible to gain an appreciation of the present and possible future dimensions of the problem by means of a general treatment of the subject. Some of the effects of water pollution will be examined briefly under three broad headings – health, ecology and property.

HEALTH EFFECTS

Water pollution remains a cause of disease in man and animals and, under certain circumstances, may still threaten the public health of the community. The epidemics of typhoid fever, cholera and dysentery associated with drinking water supplies, are largely a matter of history. Even individual cases are rare. They stem from micro-bacterial contaminants which have their origin in human and animal wastes. They are degradable and can be rendered harmless by modern treatment methods, although concentrated animal wastes present a difficult collection problem.

Today, health authorities are more concerned about the effects on health of viruses and chemical contaminants.[26] Viruses also have their origin in human and animal wastes but they are less responsive to treatment in modern facilities and have been associated with the spread of certain diseases such as infectious hepatitis. Viruses have been found in effluents from tertiary treatment plants and they are not rendered harmless by lagoons and septic tanks.[27]

Only a few diseases have as yet been traced directly to chemicals of the non-degradable or persistent variety. Exceptions include certain nitrates which in drinking water have been responsible for methemoglobinemia in infants,[28] and organo-mercury compounds which have caused damage to the central nervous system, atrophy of the cerebellum and death. Generally, concentrations of persistent biocides and industrial chemicals have not been shown to occur at levels high enough to present an acute and immediate danger to public health. Authorities are greatly concerned, however, about the cumulative

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[26] See International Lake Erie Water Pollution Board *et al., Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River, Vol. 1 – Summary,* N.J. Campbell *et al.,* eds. (Int'l Joint Commission, 1969), pp. 1, 7-9, 38-41. See also J.R. Brown, "The Pollution of Water by Chemical Agents", Donald M. McLean, "Effects of Environmental Contamination on Public Health: Water (Virus Contamination)", and R.E. Tait, "Effects of Water Contamination on Public Health: Organic Pollution", in *Background Papers: Pollution and Our Environment Conference,* I, No. A3-1-2, A3-1-3, A3-1-4 (Montreal, Canadian Council of Resource Ministers, 1966).

[27] *Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River,* p. 44.

[28] See Graham Walton "Survey of Literature Relating to Infant Methemoglobinemia Due To Nitrate-Contaminated Water", *American Journal of Public Health,* XLI (August, 1951), pp. 986-996. See also *Canadian Drinking Water Standards and Objectives 1968* (Ottawa, Dept. of National Health and Welfare, 1969), p. 24.

effects of long-term exposure at low concentrations.[29] Pesticides and biocides may reach surface waters not only through direct municipal and industrial discharges but also through broad aerial spraying, land run-off and percolation through the soil via potable underground waters. In combination with heat and with other elements, chemical reactions occur generating new products at very low concentrations which defy easy detection. Many of these substances, mercury compounds for example, are subject to a marked degree of biological magnification through the food chain. Many of them also resist conventional processes for water treatment and for both the collection and treatment of sewage. Hundreds have been found in treated water supplies at very low concentrations.

Authorities are also concerned about the health effects of long-lived radio-nuclides. Exposure to radiation, whatever the source, may have acute chronic, genetic or other effects, depending on the type of radiation and the nature and duration of exposure.[30] Radioactive sources are numerous today and are multiplying rapidly. Naturally occurring radioactivity forms a background level which has to be accepted. Fall-out from nuclear testing has been brought at least partially under control. Medical and dental uses of X-rays and radio-isotopes have been subjected to rules and guidelines. Radioactive wastes from nuclear reactors, industrial and research uses represent the major and most rapidly growing sources of radio-nuclides. They may be discharged directly into water bodies or they may enter through municipal sewers. On entering a water body, the radio-nuclides are diluted and distributed. The extent of both depends on the size, flow, temperature and other characteristics of the water body. Although releases are controlled to ensure that levels in the receiving body are maintained within prescribed standards, some of the same problems exist with radio-nuclides as with the other persistent pollutants: contamination of other elements and species, biological magnification, difficulty of isolating the effects of low concentrations. The ramifications of constant, long-term exposure to very low concentrations are of great concern.

The menace of water pollution to human health has not diminished over the years; but its character has changed. In earlier days, the menace was immediate and filled with terror as typhoid and dysentery moved from house to house and town to town. Today it is generally quiet, surreptitious and statistical, its subtle effects taking their toll not in days or weeks but in years and, in the case of genetic damage, over generations.

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[29] *Canadian Drinking Water Standards and Objectives 1968* (Ottawa, Dept. of National Health and Welfare, 1969), pp. 15, 30-31.

[30] See Anna M. Baetjer, "Radiation", in Maxcy-Rosenau, *Preventive Medicine and Public Health*, 9th ed. Philip E. Sartwell (New York, Appleton-Century-Crofts, 1965), pp. 747-750. See also *Second Report of the United Nations Scientific Committee on the Effects of Radiation* (17 GAOR, Supp. 16, Doc. A/5216, 1962). See especially Chapter III, "Somatic Effects", and Chapter IV, "Hereditary Effects."

EFFECTS ON ECOLOGICAL SYSTEMS

The effects of water pollution on plant and animal life take many forms and some have been mentioned in earlier chapters of this paper. As with effects on human health, however, knowledge of effects on plant and animal species will always lag behind the phenomena, unless nations place far greater controls on new products entering the environment. Four examples of ecological effects will be cited because they illustrate certain spatial, scale and other characteristics of importance to the role of governments. The four are eutrophication, thermal pollution, large projects and marine pollution.

EUTROPHICATION

Eutrophication is a word coined by scientists to describe the rapid aging of lakes. The principal agents of eutrophication appear to be phosphorus and nitrogen, both of which are essential to life. Under natural conditions, healthy lakes and streams contain algae which require nutrients in the form of phosphorus and nitrogen as well as carbon, calcium and iron. The algae are consumed by fish, the fish by other fish and animals, and the food chain thrives. The problem is that increasing volumes of man-made nutrients are ending up in our water bodies where they accelerate the growth of prodigious quantities of algae. Some varieties of algae do not enter the food chain and their growth is not controlled by it. As they decompose, they consume large quantities of oxygen which is then not available to fish and aquatic life. The fish and other life gradually disappear. The lake takes on a new look as algae bloom and dead fish are washed up on beaches. It also takes on a new taste and other chemicals have to be added to make even potable water palatable for human use. Gradually a lake becomes devoid of life and a hazard to health. Other uses of the water are precluded, except transportation, power generation and more waste disposal. In time, depending on its size and other characteristics, even these uses become impossible as the lake turns into a marsh and dies completely.

Although phosphorus is a major offender, the relationship between eutrophication and various compounds is not simple and is by no means fully understood. There is evidence to suggest that even minute amounts of molybdenum, cobalt and manganese may have a profound effect upon the production of algae in some lakes and under some conditions. So may the presence of vitamins. While the phenomenon of eutrophication is not fully understood, several things are evident. The sources of nutrients are many, ranging from household cleaners to industrial chemicals and agricultural fertilizers. Their number is growing rapidly. Their control is difficult and costly.[31] Their effects are widespread – hardly a lake

[31] Control after use is possible only in the case of household and industrial applications where the effluent can be contained and channelled to expensive tertiary treatment facilities. Control of the primary source, essential in the case of agricultural and forestry applications, could mean depriving these industries of significant benefits.

in the settled regions of the world is not suffering – and the cumulative impact on the biosystem could be enormous and far reaching.

THERMAL POLLUTION

High temperatures may accelerate and aggravate these effects. The amount of waste heat being returned to our water bodies from thermal power stations and industrial plants is growing. The amounts will continue to increase in proportion to economic development and power consumption. Based on estimates in the recent report of the National Energy Board, the amount of waste heat produced by thermal power plants in Canada could rise by a factor of 14 between 1966 and 1990.[32] A recent survey of projected thermal inputs to Lake Erie and Lake Ontario revealed that there will be a thirteenfold increase in waste heat discharge into Lakes Erie and Ontario over the next 30 years. By the year 2000 the waste heat input into Lake Ontario in January could be equivalent to eight per cent of the solar energy reaching the lake in that month.[33]

Thermal pollution can have a serious effect on aquatic life. A waste load that would not cause levels of oxygen to drop below limits safe for aquatic life at one temperature may do so if the temperature of the water rises. In lakes, thermal pollution can accelerate and aggravate the effects of eutrophication. On the other hand, thermal pollution can be avoided. In areas where local water bodies are inadequate for cooling, utilities do build massive cooling towers to dissipate waste heat. Waste heat can also be put to beneficial use. It has been suggested, for example, that warm waste water might be used for domestic heating. Proposals have also been made to site thermal power plants near harbours and canals required for year-round operation or near irrigation projects where the water could be used to extend the growing season and expand the range of crops. These and other possibilities, however, would require comprehensive planning and integrated management.

LARGE PROJECTS

Modern engineering skills and advancing construction techniques have combined to greatly increase the range of alternatives available to meet increased demands for water. The St. Lawrence Seaway, the Columbia River Project, the Gardiner Dam, the Canso Causeway, the harnessing of the Nelson and Churchill Rivers, are relatively small-scale examples of what the future could hold. A recent

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[32] Based on their study *Energy Supply and Demand in Canada and Export Demand for Canadian Energy 1966-1990,* the National Energy Board forecasts that thermal power production will rise from 24,130 GWH in 1966 to 335,132 GWH in 1990. Assuming a thermal efficiency of 35 per cent, they estimate that reject heat will rise from 82.5×10^{12} BTUs to $1,143 \times 10^{12}$ BTUs. (Private communication from the National Energy Board, January 30, 1970).

[33] Statement by H. Courtney Kingstone, Legal Counsel, Department of External Affairs, to I.J.C. Great Lakes Pollution Hearings, January 23, 1970, p.4.

report of the U.N. Secretary-General noted that "Major inter-basin transfers of water have been discussed for Canada and Siberia .... Although economic and engineering factors are given full weight in most of these plans, the broader environmental impact is inadequately considered."[34]

The direct and immediate benefits of the specific projects mentioned above are demonstrable and not in question. Some projects, however, have had unintended effects on plant and animal species. The completion of the St. Lawrence Seaway, for example, permitted an invasion of the Great Lakes by the sea lamprey, an eel-like marine parasite that attaches itself to larger fish. The lake trout was its most important prey. Within a few years the commercial catch fell from 5.5 million pounds to about 400 pounds.

Proposals to construct massive projects to transfer waters from northern to southern areas have brought warnings of consequences ranging from the possible destruction of plant and animal species to irreversible changes in the climate of broad regions. As a result of experience and the growing power of construction technology, scientists representing many disciplines have begun to admonish governments to devote increased attention to the possible ecological consequences of large water development projects. Often these consequences, if identified in time, can be avoided by the application of the same research and technological skills that make the project possible.

MARINE POLLUTION

The effects of pollution on marine life may represent its greatest threat to mankind. The oceans are man's largest and most efficient septic tank. Most of the waste generated on land ends up in our oceans. Some of it, as we have seen, remains in the atmosphere. Some of it decomposes to form part of the soil. But because of the inter-connectiveness of all waters draining the continent, and the other characteristics of water discussed earlier, most of it sooner or later reaches our oceans.

Pollutants washed into the sea tend to concentrate initially in estuaries and bays where they can have serious effects on marine life. The destruction of spawning and feeding beds of coastal species is a worldwide phenomenon. Placentia Bay is still fresh in the minds of Canadians. Sewage, pesticides, detergents, petrochemicals, radio-nuclides and other wastes from land-based economic activity, threaten the life in the ocean in much the same way as they threaten species in our fresh waters. "Even with the strongest abatement programs, it appears likely that (oceanic) pollution will increase alarmingly in the years ahead."[35]

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[34] United Nations Economic and Social Council, *Problems of the Human Environment: Report of the Secretary General* (Doc. E/4667, 47th Session, 1969), p. 13.

[35] Commission on Marine Science, Engineering and Resources, *Report: Our Nation and the Sea* (Washington, U.S. Gov't Printing Office, 1969), p. 2.

Land-based activity is only one source of marine pollution. The sinking of the *Torrey Canyon* in 1967 dramatically demonstrated the dangers posed by off-shore activities, and the *Arrow* in Chedabucto Bay brought home to Canadians some of their potential ramifications. Several aspects of off-shore pollution are worthy of note. The first is the large number of possible sources. Tanker disasters are only one. Off-shore drilling is another. Indeed, oil drilling from off-shore wells was the cause of Santa Barbara's agony. Ships flushing their storage tanks are perhaps the largest off-shore source. It has been estimated that the flushing of tanker storage at sea results in the annual spillage of 10 times as much oil as oozed from the *Torrey Canyon*. The second is the increased risk of tanker disasters. In World War II, the average-sized tanker was 16,000 tons. Today 300,000 ton vessels ply the seas and even larger ships are planned. Just as significant, in the last 10 years there have been 550 reported collisions involving tankers. The third aspect is the actual and potential seriousness of the effects. It is known that oil pollution can destroy waterfowl and marine life, ruin beaches and depress recreation and other industries dependent on the coastal resource affected. It is not known what the cumulative effects of oil spillage might be nor what the effects of other types of marine disasters might be, for example, a collision involving a large volume of biocides. It was an awareness of the risks[36] and the possible consequences of a disaster in northern waters, that prompted the Canadian government to proceed with legislation to control marine navigation in the Arctic.[37]

EFFECTS ON PROPERTY

The most serious effects of water pollution are those on the health of man and of the millions of other species with which he shares the biosystem. Water

[36] Based on estimates in the N.E.B. Report, *Energy Supply and Demand in Canada* . . . one can speculate on the risks associated with tanker transport in the Arctic:

> From data on the 'Manhattan' tanker experiment just completed, we would infer that tankers of 300,000 dead weight, each capable of carrying about 2 million barrels of oil, will be required. As the round trip will take a minimum of 30 days, and as one tanker will be loaded every two days and allowing for tanker inspection and repair, some twenty tankers would be required. In normal conditions, eight to ten of these will be in the Arctic waters continually. If one of these loaded tankers were to break up and only fifty percent of the cargo salvaged (an oil spill of 1 million barrels) and assuming the oil would spread out one inch thick on the water, it would create an oil slick two and one half square miles in area. If this were to hit the shore at an average width of 100 feet, the contaminated shoreline would stretch for over one hundred miles. Of course other assumptions of oil thickness, average width and percent salvaged would yield proportionally different results. (Private communication from the National Energy Board, January 30, 1970).

[37] See the remarks of the Rt. Hon. P. E. Trudeau in Canada, *House of Commons Debates*, October 24, 1969, p. 39:

> Canada regards herself as responsible to all mankind for the peculiar ecological balance that now exists so precariously in the water, ice and land areas of the Arctic archipelago . . . .

And see also the remarks of the Hon. J. Chrétien, in moving second reading of Bill C-202, Canada, *House of Commons Debates,* April 16, 1970, pp. 5937 *ff.*

pollution has other effects, however. It causes immense damage to property each year, ranging from the corrosion of property to the clogging of industrial piping. It necessitates continuous dredging of harbours and canals to maintain navigation depths. Sediments dredged may be saturated with toxic organics, metals and nutrients and their disposal can simply transfer the effects to other uses – and other jurisdictions. Polluted waters can depress real estate values. They can emit foul odours associated with gases such as methane and hydrogen sulphide. Floating garbage can completely destroy the beauty of a lake, harbour or beach.

COSTS OF WATER POLLUTION

The costs of the health, ecological, property and other effects of water pollution are most elusive. No one has yet devised a satisfactory total measure. The reasons are evident. Because of the nature of water, the costs of pollution, like its effects, are transmitted from polluter to user and from jurisdiction to jurisdiction. They pervade entire local, national and international economies. More significant, many of the most important costs cannot be expressed in dollars. We value clean water for its direct economic uses – industrial processing, navigation, and recreation. We can roughly measure the increased cost of maintaining these uses, or of sacrificing them for other alternatives as a water body becomes polluted. But we value water more for the life it sustains, for its role in the food and energy chain upon which we all depend. Yet we cannot place a monetary value on the loss of a species or on the reduced rate of photosynthesis by phytoplankton poisoned by biocides. We also value clean, life-filled water for the lift that it gives to our spirits, but these values are intangible and have no home in the market place. The global costs of polluted water are staggering in their magnitude, nature and seriousness, but significant components of the costs cannot be translated into monetary terms.

It is almost as difficult, at this stage, to gain an appreciation of the financial outlays required by the public and private sectors to reduce the pollution of our waters and to render harmless the inevitable effluent from municipal, industrial and other sources. Table 14 indicates that the annual expenditures required to provide *only* primary and secondary treatment for municipal wastes could rise from about $100 million in 1966 to $900 million in the year 2000. This is only a fraction of the financial outlays required, however. These projections assume that we do not catch up with the enormous backlog of required primary and secondary treatment facilities until the year 2000. They also neglect completely the more expensive tertiary treatment facilities that are required to remove the nutrients that cause eutrophication. They neglect the outlays for waste treatment by industry and marine transport. They also neglect the additional forms of treatment that will be necessary to remove or neutralize the hundreds of thousands of new chemicals, and their secondary by-products, added to our effluents by an unregulated technology. They ignore the outlays required for provincial, national and international research, planning, monitoring and policing.

The financial outlays required to restore the quality of our waters and maintain them at acceptable levels of purity are enormous and growing rapidly. Canadians, in common with other peoples, must accept them both as a price of progress and as a matter of survival. Each order and level of government in Canada has a vital role to play in devising and applying strategies for water quality management. The range of strategies, however, and the order of government in the best position to discharge them, will vary from problem area to problem area.

THE PROBLEM AREAS

Where are the major water quality problem areas now and where are they likely to be in the foreseeable future? It is impossible to provide a detailed and definitive answer to this question but, fortunately, neither a detailed nor a definitive answer is required for the purposes of this study. The general demographic, economic, technological and other trends explored in Parts Two and Three, coupled with the fundamental characteristics of water discussed at the beginning of this chapter, provide a strong indication of the areas most likely to contain the major sources of water pollution and to experience its greatest effects and costs.

Referring to the map at the beginning of Part Three, the reader will note the shaded area. It shows what geographers refer to as the "ecumene", the area of more or less continuous settlement. It contains the overwhelming majority of Canadians along with their cities, towns, industries, farms and transportation networks. Recalling the population projections in Figure 6 and Tables 4 and 5, it is evident that this area will continue to provide the main habitat for Canadians. This will be true even if the most optimistic speculation respecting northern development is realized.[38]

It follows that the rivers, lakes and coastal estuaries draining the ecumene will experience the greatest pressures of growth and will require the most effective management strategies to maintain and enhance their water quality, let alone to avoid its progressive deterioration. Many rivers, lakes and coastal areas beyond the ecumene and in the north will also experience serious water quality problems. The problems posed by northern oil development have been described and reference has been made to the fact that a single mine, chemical or pulp and paper mill can generate the waste equivalent of a large city. Also, major diversions could involve these watersheds. Northern waters will therefore also require vigilant and effective management.

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[38]The Yukon and Northwest Territories now contain around 49,000 people. If this population were to increase ten times in the next thirty years, a fantastic rate of growth even under the most favourable circumstances, it would still total less than 500,000 or less than 1.5 per cent of the medium projection of Canada's total population in the year 2000.

It is in the rivers and lakes draining the ecumene that we also find today's major water quality problems. Because of the huge scale of Canada's watersheds, these problems are concentrated in a relatively small number of large river basins. In the west there are the Fraser and the Okanagan; in the Prairies, the Saskatchewan-Nelson and a number of its major tributaries such as the Qu'Appelle, Assiniboine, Souris, Red and Winnipeg; in central Canada, the Great Lakes-St. Lawrence system including the Ottawa River; and in the Atlantic region the Saint John, St. Croix, Exploits and Miramichi.

This list does not include all of the larger systems seized with pollution problems, nor can it include the hundreds of tributaries, lakes, coastal estuaries and bays, that have water quality problems of a local, provincial and, in some cases, national and international significance. At the same time, it should be observed that the basins mentioned now contain over 70 per cent of Canada's population. By the year 2000, they could contain nearly 90 per cent, along with most of our major cities and most of our agriculture, forestry and other pollution-intensive industries.

SOME RELEVANT CHARACTERISTICS OF WATER QUALITY MANAGEMENT

A number of characteristics of water quality management relevant to the role of governments may be deduced from the above. Most of them are shared by the other transcendent resource, air. In fact, the differences are so minor in the case of five of the characteristics, that any discussion would essentially repeat the treatment in the previous chapter. The five are: clean water as a public good; the concentration of water pollution in urban regions; the externality of the sources of water pollution; the rapid rate of growth in the variety of water pollutants; and resource interdependence. The phenomenon of resource interdependence is much stronger in the case of water than air, because it is the ultimate receptacle of most pollutants. This was drawn out in the above discussion of land and atmospheric sources of marine pollution and applies equally to lakes and rivers.

Transboundary movement is another characteristic shared by air and water pollution. It requires brief elaboration, however, because it is such a dominant feature of Canadian water quality management. Referring to the map at the beginning of Part Three, one can see that most of the large surface drainage basins overlap the boundary between Canada and the United States, or the boundaries between the provinces, or the boundaries between the provinces and the northern territories. The major basins do all three. Many of the tributaries of these basins, of course, do not. In recent years, large underground aquifers have been discovered which lie across international and

provincial boundaries. Certain semi-enclosed arms of the oceans also overlap political boundaries.[39]

The transboundary movement of water pollution can be expected to increase greatly in the future. From the trends outlined in earlier chapters, it is evident that this will be especially true in four areas: the Lower Fraser, the Saskatchewan-Nelson, the Saint John, and most of all, the Great Lakes-St. Lawrence. The latter drains eight states and two provinces, all containing large and rapidly expanding concentrations of people and industry. Much of the wastes generated by this activity inevitably pass through Ontario and Quebec. The International Lake Erie Water Pollution Board has already found "that Lake Erie, Lake Ontario and the international section of the St. Lawrence River are being polluted on both sides of the boundary (U.S.-Canada) to an extent that is causing and is likely to cause injury to health and property on the other side of the boundary."[40] In light of the anticipated growth of the Great Lakes region on both sides of the border, it seems most unlikely that the quality of this shared resource can be restored and maintained without the establishment of agreed goals at the international level and the concerted application by all governments of a wide range of planning, regulatory, financial and other strategies to achieve these goals. This requires some type of structure for integrated management.

Integrated management is one of the most important characteristics of water quality management relevant to the role of governments. Water management authorities at the provincial, national and international level are now generally agreed that integrated management is a prerequisite to the restoration

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[39] Georgia Strait and Juan de Fuca Strait lie between British Columbia and the State of Washington, and overlap the boundary between Canada and the United States. Dixon Entrance and Portland Canal lie between British Columbia and Alaska and also overlap the boundary between Canada and the United States. Chaleur Bay divides Quebec from New Brunswick; Northumberland Strait divides Prince Edward Island from New Brunswick and Nova Scotia; and Chignecto Bay, at the head of the Bay of Fundy lies between New Brunswick and Nova Scotia.

[40] International Lake Erie Water Pollution Board *et al., Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River*, I, p. 7:

> The Advisory Boards have concluded from flow studies conducted by United States and Canadian agencies, that there is substantial mixing of waters in the lakes to the extent that concentration levels of polluting materials are remarkably uniform throughout extensive areas of each lake. Thus there appears to be no doubt that all major sources of pollution to the lakes have contributed directly, or indirectly, to their generally degraded condition. *Ibid.*

and maintenance of water quality in all waters affected by substantial development and use. Its required extent and form may vary from area to area, depending on the nature and complexity of development, the degree of interdependence between uses, and on the other characteristics of water mentioned above.

Integrated water quality management has come to mean several things, three of which are especially significant. First, it means a process of goal setting. The development, use and quality standards of the resource should stem from and reflect the changing economic and social goals of the region in question, be it urban, provincial, or transboundary. Second, it means a process of planning as comprehensive as the demand region necessitates, as evolving technology requires and as planning techniques and management skills permit. In the future, the planning process should not only identify the range of alternatives available to meet the demands imposed on a basin, aquifer or coastal area. It should also assess the impact of these alternatives on the present and projected uses of the resources of the region, including their primary biological uses. The alternatives identified and assessed should include more than those involving physical development. The goals for all or a part of a water body can often be most effectively achieved through non-development measures such as land-use control. Moreover, since many of the costs and benefits of water uses that require higher quality standards are intangible and do not lend themselves to objective measurement, the planning process should be as responsive as possible to the wishes of the people concerned. Third, integrated management means respecting the hydrological unity of the water body. In a river basin, for example, the development and operation of reservoirs upstream for power or flood control should be integrated with the development and operation of projects downstream for the same or other purposes. Conversely, the installation and operation of sewage treatment facilities by a community or industry downstream must be integrated with the installation and operation of similar treatment facilities upstream. Otherwise, downstream communities and industries could be releasing clean water into dirty rivers at great cost and to little or no avail. The same principles apply to an underground aquifer, a lake, estuary or coastal bay.

Although the need for integrated management is recognized and accepted it is normally difficult to achieve in a federal state, especially with regard to transboundary waters. This has been the experience not only in Canada, but also in the United States and West Germany. Many of the reasons for this stem from the fact of divided jurisdiction. In Canada, both proprietary rights and legislative jurisdiction over waters are divided between the federal and provincial governments. There are only two areas in which this is not the case, the northern territories which comprise 40 per cent of the nation's surface, and the sea and seabed beyond the recognized boundaries of the coastal

provinces and out to the limits established by national claim and international convention. Within the boundaries of the provinces, however, both orders of government possess significant and sometimes overlapping responsibilities.[41] In view of the range of water uses and the functions and activities involved in their management, this situation seems certain to continue under any future division of powers that can claim to be federal.

Given the fact of divided jurisdiction, integrated management requires a structure within which all jurisdictions, competences and capabilities can be brought together for joint goal setting, planning and operation. There are many water bodies, situated wholly within a province, in which this should not be a problem. Their development, use and operation is mainly of provincial concern. The jurisdiction of the federal government may extend to one or two uses, the significance of which may be minor and the exercise of which may not affect, or be affected by, the uses under provincial jurisdiction. The same could be true of many interprovincial streams and also of many tributaries of boundary waters and international rivers. In these cases, the degree of integration required for effective management might be achieved through a wholly provincial or interprovincial structure that involved or cooperated with the federal agencies concerned as required or when requested.

On the other hand, many major water bodies involve the development and operation of important uses that come under federal jurisdiction, and equally important and interdependent uses that come under the jurisdiction of one or more provincial governments. While these water bodies normally fall into one of the transboundary categories, they may be intra-provincial. In international boundary waters, of course, the same range of uses may come under the jurisdiction of two or more governments in the United States. It is in some of these areas that integrated water management will be most essential in the future. Intergovernmental structures will be required for such management.

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[41] See Dale Gibson, "The Constitutional Context of Canadian Water Planning" (Paper A3-1 in Background Papers, Water Workshop Seminar, Canadian Council of Resource Ministers, unpublished, 1960; "Water Resource Development in Canada: A Perspective", in *Canadian Papers: Int'l Conference on Water for Peace* (Ottawa, Department of Energy, Mines and Resources, 1967), pp. 7-8; Dale Gibson, *Constitutional Jurisdiction over Environmental Management in Canada* (Unpublished, 1970); Bora Laskin, "Jurisdictional Framework for Water Management", in *Resources for Tomorrow Conference: Background Papers,* I (Ottawa, Queen's Printer, 1961); Canadian Council of Resource Ministers, *The Administration of Water Resources in Canada* (1965).

PART SIX

THE ROLE OF GOVERNMENTS IN ENVIRONMENTAL MANAGEMENT

Chapter XVI

Summary Considerations

It is evident from the foregoing analysis that environmental management can be accomplished through a broad range of research, planning, financial and other strategies involving many different functions applied to hundreds of different activities. These strategies have as their common goal the maintenance or the enhancement of the quality of the environment. They generally seek to achieve this goal in three different ways, singly or in combination. The first involves treating or reducing the pollutants generated by an activity before they enter the environment. The second involves regulating the location of the activity giving rise to the pollution, or the location of the recipients, or both. The third attempts to modify or eliminate the activity that gives rise to the pollutants. Moreover, under the existing political structure, there are only four jurisdictional situations in which the strategies may be applied to achieve these ends. The first pertains to pollution within a province which has its source and its effects both contained within the province. The second pertains to pollution in a province or territory which has its source in another province or territory or which affects another province or territory. The third pertains to pollution in Canada which has its source in another country or which affects another country. The last pertains to pollution within a province which originates on lands or from facilities under federal ownership or jurisdiction.

Effective management strategies applied in any one of these jurisdictional situations necessarily concerns both orders of government. This appears to be an almost inescapable conclusion from the foregoing analysis. It flows not only from the fact that environmental problems are dominated by spillovers. It flows also from four characteristics that stand out in each part of the analysis: ecological interdependence; physical interdependence; problem interdependence; hence, jurisdictional interdependence. The overriding corollary of this, of course, is intergovernmental cooperation, at all levels and in all possible forms. It is difficult, if not impossible, to visualize any political or institutional structure, or any system of powers, that would reduce the importance of such cooperation or that would work without it.

This chapter will attempt to bring together briefly the main considerations respecting the role of governments that have already been drawn out in the preceding parts: in Part Two on the source of environmental deterioration; in Part Three on the urban regions; and in Part Four on the rural and territorial area. The considerations that emerge from the above analysis of air and water resources in Part Five have not yet been drawn out so they will be treated at greater length. It is convenient to summarize these considerations under the broad headings that have been employed throughout. The discussion begins with an examination of planning followed by regulation, financing, research and information systems.

PLANNING STRATEGIES

The important role of comprehensive planning has been stressed repeatedly. It emerged from the analysis of urban congestion, blight and sprawl, visual pollution, noise pollution, solid waste disposal, and water and sewage collection and treatment. In Chapter XI, the discussion of urban regions concluded that, while the urban region is the appropriate level at which to apply a wide range of strategies, "By and large . . . it is those functions, activities and strategies associated with the preparation and implementation of comprehensive plans that can be most effectively applied at the level of the urban region."[1]

A parallel conclusion came out of the analysis of environmental problems in rural and territorial areas, of agriculture and forestry, mining, transportation and recreation. With special reference to rural land and scenic resources, Chapter XIII concluded that "the provinces are generally in the best position to undertake those functions, activities and strategies associated with the preparation and implementation of comprehensive plans."[2]

Noting the breadth and depth of federal and provincial activities in urban regions, and the fact that these will almost inevitably increase in the future, Part Three also concluded that both senior orders of government would have to be involved in urban planning and development if it is to be comprehensive and effective. Part Four arrived at a similar conclusion concerning federal involvement in provincial planning for rural and territorial areas. Both parts also questioned the need for continuing the immunity of federal (or provincial) agencies, and of private enterprises subject to federal regulation, from the application of provincial (or urban) planning and environmental controls that do not substantially interfere with their activities.

The important role of comprehensive planning recurred in the analysis of air and water resources. Integrated management in these fields is possible only within the context of overall plans that comprehend all sources, effects, causal relationships and possible strategies. Because of the transcendent character of these

[1] p. 109.
[2] p. 137.

resources, however, and the growing significance and areal scale of interrelationships between air, land and water pollution, comprehensive planning takes on dimensions that are jurisdictionally more complex and more difficult.

There are three different cases in which this type of planning may be necessary. In the first case, the air, land or water area concerned lies wholly within a province and is polluted by sources that also lie within the province. In this case, provincial governments now possess the powers requried to effect comprehensive planning, except in respect of environmental spillovers from public or privately-owned facilities that are under federal jurisdiction, and of certain water uses that come under federal jurisdiction. The former has been mentioned above, and the previous chapter suggested that where the water uses under federal jurisdiction are of minor significance to the area in question, comprehensive planning and other measures required for integrated management might be achieved through a wholly provincial structure that involved or cooperated with the federal agencies concerned, as required or when requested. In some cases, the management of such water uses might be delegated to the province concerned.

In the second case, the area concerned lies within one province but the sources of pollution are in another province. There is not now any constitutional barrier to the provinces concerned cooperating to establish structures to undertake joint comprehensive planning and other measures required for integrated management, with or without the participation of the federal government. The above remarks respecting water uses under federal jurisdiction, apply equally here. In view of the analysis, however, it is hard to avoid the conclusion that the federal government should be in a position to act directly over polluters, employing planning and other measures required for integrated management, where there is evidence that pollution is reaching unacceptable levels, posing a threat to the health of humans, to aquatic life, animals, plants and the biosystem generally, but where the provinces concerned are unable to agree upon, or to apply, the necessary management measures.

In the third case, the area concerned lies within Canada but the sources of pollution are outside of Canada, or conversely. In this case, the provinces are unable to establish the necessary structures to undertake comprehensive planning and other measures required for integrated management. Again, it seems difficult to argue that the federal government should not be in a position to take the necessary action to initiate, prepare and implement supra-provincial, national and international management plans. On the contrary, in light of the analysis, it would appear to have an obligation to do so. It can do so, of course, only with the cooperation of foreign governments. And it should do so in cooperation with the provincial governments concerned.

The cooperation of provincial governments is clearly desirable, if not essential, in the preparation and implementation of comprehensive plans and other measures required for the integrated management at the supra-provincial and

international level. This stems from a number of factors. The implementation of spatial plans could require the use and application of provincial powers derived from proprietary rights. It could also affect vital provincial and local priorities and interests. Provincial governments and their agencies should therefore be involved to ensure that provincial and local interests are recognized and protected, and also to ensure that any international and national obligations undertaken are implemented with full knowledge of such interests. Provincial involvement is also desirable because it may be most efficient to discharge many of the national or international obligations by delegation to provincial and local government agencies.

REGULATORY STRATEGIES

Environmental management requires the employment of a wide range of regulatory strategies. Many of these can be applied most effectively at the sub-provincial level. Examples of preventive and curative as well as punitive strategies have been cited throughout the analysis of urban regions and rural and territorial areas. Most of these related directly or indirectly to the control of land use or to the preparation and implementation of urban and rural development plans.

Regulatory strategies are no less important in the field of air and water quality management. In general, regulatory (and other) strategies may be aimed at controlling the volume and quality of discharges into the air or water environment, or at controlling the activity giving rise to the discharges. These two approaches are sometimes contrasted as "treatment of the symptoms" and "treatment of the cause". The distinction between these two approaches is important since they are generally responsive to different types of regulatory strategies and since these strategies can often be applied more effectively by one order of government than by another.

The "treatment of symptoms" includes a wide variety of technical devices such as precipitators for stack gases or after-burners for internal combustion engines in the case of air, and primary, secondary or tertiary treatment facilities in the case of water. As a general rule, measures to regulate the volume and quality of discharges from specific sources are most effectively applied at the local or watershed level. This is true even where criteria respecting discharge volumes and ambient air and water quality standards may stem from international agreements or from national actions.

The reasons for this are clear. In the case of air pollution, thousands of different sources may contribute to the deterioration of air quality in an urban region: hundreds of thousands, if one considers each motor vehicle to be a separate source. The spatial distribution of each source is unique to each region, in fact, to each part of each region. At the micro-urban level, no simple relationship exists between tolerance levels, air quality objectives and emission standards. They are a function of meteorological, topographical and structural factors which vary from area to area and source to source. In the case of water pollution, this is not as

dominant a characteristic. Because liquid sewage is usually collected and brought together at treatment plants or outfalls there are fewer points at which waste enters a water body. The relationship between tolerance levels, sewage volumes and quality standards, however, is exceedingly complex and varies from water body to water body.

This has several implications. First, while tolerance levels for different biological species, or general criteria respecting the quality of ambient air or water for different uses, or even criteria respecting allowable emissions from different sources, may flow from international and national research, in the final analysis they must be applied at the local or watershed level. They must be embodied in quality criteria or discharge standards that relate to specific sources or types of sources that reflect the unique topographical, hydrological, meteorological and other conditions of a specific urban region or water body. This can best be done by agencies operating at the urban or watershed level and familiar with local conditions. These would often be agencies of the provincial government although, where the province has delegated the responsibility, they may be agencies of an urban or other local government. They could also be agencies of the federal government. Second, while sophisticated detection and monitoring devices may flow from international or national research they, too, must be installed, operated and maintained at the local or watershed level. Again, agencies operating at this level are generally in the best position to undertake the hour-by-hour, day-by-day monitoring of discharges, and of ambient air or water quality, to determine if they fall within acceptable or prescribed limits. Such agencies may also be in the best position to initiate punitive action against offenders, although this avenue should presumably be open to any body, private or public, at least to the extent that minimum discharge volumes and air and water quality standards may be emdodied in legal codes. Third, where national information systems are required either for national purposes, or as part of Canada's agreed contribution to an international system, it may often be most efficient to have monitoring, air and water sampling and other devices installed, operated and maintained by agencies operating at the local, urban or watershed level.

Since symptomatic treatment is frequently most amenable to regulatory measures applied at local, urban or watershed levels, it seems evident that provincial governments need to be in a position to establish and enforce preventive, curative and punitive regulatory measures within their boundaries. As discussed above under planning, however, there are three jurisdictional cases in which the federal government should also be in a position to apply preventive and curative as well as punitive regulatory measures directly over polluters, and to undertake any necessary supporting functions and activities. The first is the case of interprovincial movements of air or water pollution, where the provinces concerned have been unable to agree on acceptable standards and on effective measures to achieve them. The second is the case of international movements of air and water pollution, where the provinces are unable or unwilling to accept the type or degree of delegation

required to enforce international obligations. The third arises where the provinces are unable to, or have failed to, reduce air and water pollution below a level that poses an immediate or foreseeable danger to the health of man and other species of the biosystem, or in the event of periodic emergencies of pending disasters. Again, in light of the analysis in Parts Two and Five, it seems extremely difficult to argue that the federal government should not be in a position to act in these three jurisdictional cases.

Regulatory strategies aimed at controlling the volume and quality of discharges into air and water can be extremely important from the perspective of those affected by the pollution whether they be expressway users, fishermen or fish. These strategies, however, do not reduce the quantity of waste produced. The wastes may be simply shifted from one medium to another or, preferably, they may be recycled or converted into a usable product and thus place less immediate pressure on environment.

The alternative approach, to control the activity generating the waste, is more promising. In the long run, it may be the only approach compatible with survival. It involves reducing the waste residuals produced. This may be achieved by the elimination of the source, replacing the internal combustion engine with another mobile power plant, for example, or shifting from chemical to biological methods of pest control. Or it may be achieved by modifying the inputs used by existing sources, eliminating lead in gasoline additives, for example, or shifting from high sulphur to low sulphur coal and oil, or removing phosphates from detergents.

Action by the federal government is usually the most effective way of applying strategies aimed at the primary sources of pollution. Often it is the only way. Many potential air and water pollutants can be eliminated during the design and manufacture of various products or during the refining of fuels. As demonstrated in Part Two, an increasing number of these products are based upon foreign technology generated within multinational corporations. Only the federal government is in a position to influence the character of these sources on behalf of the nation as a whole. The federal government can initiate and conclude international agreements for this purpose. It can impose restrictions on the importation, or on the interprovincial movement, of such products as pollution-intensive fuels, fertilizers and biocides and it can also prescribe the allowable level of certain constituents, and it can regulate the importation and interprovincial sale of pollution-intensive equipment and commodities.

FINANCIAL STRATEGIES

Financial and tax measures can be important components of any environmental management strategy. The discussion of urban congestion, blight and sprawl, it will be recalled, stressed the importance of financial, taxation and other economic and social measures. So did the discussion of visual pollution, noise pollution, and the side effects of mining and of land and marine transportation. In

the form of licence fees, effluent charges and other levies, financial and tax measures underlie the broad and increasingly important field of incentive strategies first mentioned in Part One.

These measures are also vital to effective air and water quality management strategies, whether they are aimed at the emissions from a source or at the source itself. Various types of grants or tax relief may be used to assist municipalities, industries and other polluters to undertake necessary abatement measures or to divert funds into research and other desired activities. Various types of taxes and fees may also serve to induce or compel industrial and other polluters to modify production processes, change the composition of raw materials used in production processes, or generally to treat pollution as a cost of production. Special taxes on particularly dangerous but necessary substances might well lead to greater economy and care in their use, as well as raise funds to cover all or some of the environmental costs associated with their use.

The provincial governments have almost the same ability to use tax and financial measures in air and water quality management strategies as does the federal government. The major exceptions apply to pollution sources external to a province. Only the federal government is in a position to employ import duties, for example, a power that could be quite significant.

RESEARCH STRATEGIES

The future effectiveness of environmental management rests on continuous and vigorous research in both the natural and social sciences. Certain characteristics of research and technology were discussed at length in Part Two. It was concluded that all orders of government have a continuing and vital role to play in initiating, undertaking and sponsoring research, as well as any functions necessarily associated with research, such as information systems within their jurisdictions. This theme emerged repeatedly in various forms throughout the analysis of urban regions and rural and territorial areas.

Research strategies are no less crucial to effective air and water quality management. Some of the research required can be done best at the national and international level. This stems from many factors – the global scale, complex interrelationships and rapid rate of change of many of the phenomena being studied; the growing scale of the research required; and the growing need for national governments to share scarce resources in order to undertake all of the research required. Furthermore, there are many fields in which the results of research could have general application and would not be limited to specific areas. Several examples could be cited. They would include research aimed at establishing tolerance levels for and identifying cause and effect relationships between pollutants and diseases of humans, plants and animals. Such research provides a scientific basis for the continuing evolution of safe discharge volumes or of ambient air and water quality standards. These in turn may be employed as advisory guides

or may find their way into legal codes established by the appropriate orders of government or by international conventions. Examples would also include research aimed at replacing or modifying major sources of pollution such as the internal combustion engine. In such areas, national effort and international cooperation are both desirable and necessary.

On the other hand there are many fields where research must take into account physical, social and economic factors unique to a specific urban region or area of a province. These cases are most likely to be identified at the local, urban or provincial level and, depending on the circumstances, it may be most efficient for the research to be sponsored by or undertaken in facilities owned or controlled by large urban or provincial governments. This would also assist provinces and large urban regions in developing the capability required to maintain access to and apply research conducted at the national and international level.

INFORMATION SYSTEMS

The type and scale of information systems required for environmental quality management are enormous. Different types of systems are required to identify the increasing range of pollutants. They are required to measure the amount of each pollutant in the environment and to monitor the duration of exposure by humans, animals and plants at different points on the globe. They are required for information exchange between government and public, between administrator and scientist and between people working in various fields of knowledge. They are required for the effective application of planning, regulatory, financing, research and other functions and strategies, and hence they are required by governments operating at the urban, provincial, national and international levels. Urban and provincial governments may require certain types of information for daily monitoring of specific sources or for developing planning standards to govern the location of new sources. The federal government may require the same and other data for similar purposes, or for research and publication, or for aggregation on a provincial, national and other basis to ensure that national criteria are being met and international agreements are being honoured.

The capability of information systems is continually increasing with expanding technology in the electronic computer, communications satellite and other fields. Factors such as familiarity with and proximity to specific sources may suggest that certain types of systems be operated and maintained by urban or provincial governments. Other factors may suggest that other systems be operated and maintained at the provincial, national and international level by the federal government. These factors would include, for example, geographical scope in the case of satellite monitoring, or economies of scale in the case of laboratory facilities required to identify exotic pollutants present at very low levels, or uniformity of sampling techniques to ensure national and international comparability of data.

Furthermore, efficiency may make it desirable and technology may make it possible to integrate certain systems for certain purposes at the provincial, national and even the international level.

All of which again underlines the overriding need for intergovernmental cooperation in the urgent tasks of environmental management. No political or institutional structure and no distribution of powers and responsibilities can work without it. Coupled with an appreciation of, and a respect for, the appropriate role of the different orders of government, it is the essential key to the successful management of tomorrow's environment.

APPENDICES

Appendix 1[a]

Growth,of Total, Urban, and Rural Population: Canada and Each Province 1901-1966 ('000's)

Census Year	Components of Population	Canada[bc]	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario	Manitoba	Sask.	Alta.	B.C.
1901	Total	5,592	221	103	460	331	1,649	2,182	255	91	73	179
	% of Canada	*100*	*4.0*	*1.9*	*8.2*	*5.9*	*29.5*	*39.0*	*4.6*	*15.6*	*1.3*	*3.2*
	Urban	2,014	NA[e]	15	129	77	654	936	70	14	19	90
	% Each Prov.	*37.5*	NA	*14.5*	*28.2*	*23.3*	*39.7*	*42.9*	*27.6*	*15.6*	*25.4*	*50.5*
	Rural	3,357	NA	88	330	254	994	1,247	185	77	54	88
	% Each Prov.	*62.5*	NA	*85.5*	*71.9*	*76.7*	*60.3*	*57.1*	*72.4*	*84.4*	*74.6*	*49.5*
1921	Total	9,051	263	89	524	388	2,361	2,934	610	758	588	524
	% of Canada	*100*	*2.9*	*1.0*	*5.8*	*4.3*	*26.1*	*32.4*	*6.7*	*8.4*	*6.5*	*5.8*
	Urban[d]	4,165	NA	17	235	137	1,223	1,724	253	127	181	267
	% Each Prov.	*47.4*	NA	*18.8*	*44.8*	*35.2*	*51.8*	*58.8*	*41.5*	*16.8*	*30.7*	*50.9*
	Rural	4,623	NA	72	289	251	1,138	1,209	357	630	408	258
	% Each Prov.	*52.6*	NA	*81.2*	*55.2*	*64.8*	*48.2*	*41.2*	*58.5*	*83.2*	*69.3*	*49.1*
1951	Total	14,009	361	98	643	516	4,056	4,598	777	832	940	1,165
	% of Canada	*100*	*2.6*	*0.7*	*4.6*	*3.7*	*29.0*	*32.8*	*5.5*	*5.9*	*6.7*	*8.3*
	Urban	8,729	155	25	350	221	2,709	3,333	435	253	447	799
	% Each Prov.	*62.3*	*43.3*	*25.1*	*54.5*	*42.8*	*66.8*	*72.5*	*56.0*	*30.4*	*47.6*	*68.6*
	Rural	5,255	206	74	293	295	1,347	1,265	342	579	492	366
	% Each Prov.	*37.5*	*56.7*	*74.9*	*45.5*	*57.2*	*33.2*	*27.5*	*44.0*	*69.6*	*52.4*	*31.4*

	Rural Non-Farm[f]	2,828	191	47	112	145	766	678	214	398	340	110
	% Each Prov.	*20.1*	*53.0*	*48.0*	*17.4*	*28.1*	*18.8*	*14.7*	*27.7*	*47.8*	*36.2*	*9.5*
	Rural Farm	2,553	15	27	185	154	591	668	122	181	150	262
	% Each Prov.	*18.1*	*4.1*	*27.5*	*28.7*	*29.8*	*14.5*	*14.6*	*15.7*	*21.8*	*16.0*	*22.5*
1966	Total	20,015	493	109	756	617	5,781	6,961	963	955	1,463	1,874
	% of Canada	*100*	*2.5*	*0.5*	*3.8*	*3.1*	*28.9*	*34.8*	*4.8*	*4.8*	*7.3*	*9.4*
	Urban	14,727	267	40	439	312	4,525	5,593	646	468	1,007	1,410
	% Each Prov.	*73.6*	*54.1*	*36.6*	*58.1*	*50.6*	*78.3*	*80.4*	*67.1*	*49.0*	*68.9*	*75.3*
	Rural	5,288	227	69	317	304	1,256	1,367	317	487	455	463
	% Each Prov.	*26.4*	*46.0*	*63.4*	*42.0*	*49.4*	*21.7*	*19.6*	*32.9*	*51.0*	*31.2*	*24.7*
	Rural Non-Farm	3,374	218	38	272	253	762	886	157	207	178	378
	% Each Prov.	*16.9*	*44.2*	*35.0*	*36.0*	*41.0*	*13.2*	*12.7*	*16.3*	*21.7*	*12.2*	*20.2*
	Rural Farm	1,914	8	31	45	52	494	482	160	280	278	85
	% Each Prov.	*9.6*	*1.7*	*28.4*	*6.0*	*8.4*	*8.5*	*6.9*	*16.6*	*29.3*	*19.0*	*4.6*

[a]Table compiled by C.I. Jackson based on data from Stone, *Urban Development in Canada,* p. 29 with 1966 data from D.B.S., *1966 Census of Canada: Population, Rural and Urban Distribution,* I(1-8) (Cat. 92-608, March, 1968).

[b]Canada includes Newfoundland for all years.

[c]Total for Canada exceeds sum of provincial figures because of population of Yukon and Northwest Territories.

[d]The 1921 and 1951 urban-rural figures are those standardized by Stone to make them comparable with the definition of urban used in the 1961 and later census.

[e]The urban-rural ratio is not available for Newfoundland before 1951. The first column therefore shows the percentage of the population of Canada excluding Newfoundland.

[f]"Non-Farm" first became a majority of rural population before 1931 for B.C. (and probably Nfld.); before 1941 for N.S. and Ontario; before 1951 for N.B.; and before 1961 for P.E.I., Quebec and Canada as a whole. By 1971, Manitoba will have joined this list and probably also Saskatchewan.

Appendix 2[a]

Projected Growth of Total, Urban, and Rural Population: Canada and Each Province 1981-2001 ('000's)

Year	Components of Population & Range of Projections		Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.
1981	Total:	High	27,129	644	118	833	679	7,594	10,094	1,124	1,054	2,124	2,899
		% of Canada	*100*	*2.4*	*0.4*	*3.1*	*2.5*	*28.0*	*37.1*	*4.2*	*3.9*	*7.8*	*10.6*
		Low	24,858	564	108	747	615	7,120	9,153	1,018	966	1,801	2,764
		% of Canada	*100*	*2.3*	*0.4*	*3.0*	*2.5*	*28.6*	*36.8*	*4.1*	*3.9*	*7.3*	*11.1*
		Medium	25,362	580	114	763	629	7,261	9,333	1,040	988	1,841	2,813
		% of Canada	*100*	*2.3*	*0.5*	*3.0*	*2.5*	*28.6*	*36.8*	*4.1*	*3.9*	*7.3*	*11.1*
	Urban:	% Each Province	*85.4*	*67.0*	*54.1*	*70.9*	*66.1*	*89.4*	*89.1*	*79.3*	*69.5*	*84.4*	*84.4*
		High	23,168	432	64	591	449	6,779	8,899	891	733	1,792	2,447
		Low	21,229	378	58	530	407	6,366	8,155	808	671	1,520	2,332
		Medium	21,654	389	62	541	416	6,491	8,316	825	687	1,554	2,374
	Rural:	% Each Province	*14.6*	*33.0*	*45.9*	*29.1*	*33.9*	*10.6*	*10.9*	*20.7*	*30.5*	*15.6*	*15.6*
		High	3,961	212	54	242	230	815	1,195	233	321	332	452
		Low	3,629	186	50	217	208	754	998	210	295	281	432
		Medium	3,708	191	52	222	213	770	1,017	215	301	287	439
2001	Total:	High	41,568	899	129	919	748	10,537	17,003	11,372	1,107	3,537	5,328
		% of Canada	*100*	*2.2*	*0.3*	*2.2*	*1.3*	*25.4*	*41.2*	*3.3*	*2.7*	*8.5*	*12.8*
		Low	30,345	568	92	626	520	8,200	12,063	960	854	2,121	4,333
		% of Canada	*100*	*1.9*	*0.3*	*2.1*	*1.7*	*27.1*	*40.0*	*3.2*	*2.8*	*7.0*	*14.3*

	Medium	33,801	656	113	704	588	9,112	13,420	1,076	966	2,389	4,777
	% of Canada	*100*	*1.9*	*0.3*	*2.1*	*1.7*	*27.0*	*39.7*	*3.2*	*2.9*	*7.1*	*14.1*
Urban:	% Each Province	*94.1*	*80.5*	*74.1*	*83.9*	*81.8*	*96.4*	*95.6*	*90.0*	*87.6*	*94.9*	*92.5*
	High	39,116	723	96	771	612	10,158	16,255	1,235	842	3,357	4,929
	Low	28,555	457	68	525	425	7,905	11,533	864	650	2,013	4,008
	Medium	31,798	528	84	591	481	8,784	12,829	968	846	2,267	4,419
Rural:	% Each Province	*5.9*	*19.5*	*25.9*	*16.1*	*18.2*	*3.6*	*4.4*	*10.0*	*2.4*	*5.1*	*7.5*
	High	2,452	176	33	148	136	379	748	137	265	180	399
	Low	1,790	111	24	101	95	295	530	96	204	108	325
	Medium	2,003	128	29	113	107	328	591	108	120	122	358

[a]Compiled from Systems Research Group, *Canada: Population Projections to the Year 2000* (Toronto, 1970).

APPENDIX 3

Indices of Federal Urban Involvement

City	Federal[a] Employees	Payroll[b] ($)	Land owned[c] (acres)	Rental space[d] (square feet)	Taxes & grants in lieu of taxes paid to municipal school authorities ($)
Montreal	26,346	17,221,000	744.6	7,756,688	20,875,632
Toronto	19,445	16,087,000	49.8	4,274,913	5,026,336
Vancouver	11,286	5,562,000	1,141.2	2,929,755	2,431,943
Winnipeg	6,683	4,622,000	357.9	3,414,337	2,479,424
Ottawa-Hull	57,490	32,601,000	5,112.5	21,020,216	11,974,264
Hamilton	1,486	698,000	21.1	680,583	417,347
Quebec	4,976	2,565,000	320.0	1,455,833	1,309,010
Edmonton	5,363	2,545,000	115.7	1,178,235	765,138
Calgary	3,435	1,624,000	263.7	2,336,606	801,701
Windsor	1,704	726,000	26.9	322,780	260,000
London	4,838	2,379,000	535.9	3,520,949	1,283,860
Halifax	9,743	4,362,000	381.7	4,295,935	3,273,947
Regina	1,666	824,000	1,322.8	634,778	413,736
TOTAL	154,461	91,816,000	10,393.8	53,821,608	51,312,338

[ab]D.B.S., *Federal Government Employment in Metropolitan Areas* (Cat. 72-205, July, 1970). Figures as of June 30, 1968.
[cd]Government of Canada, *Central Real Property Inventory* (Dept. of Public Works, April, 1969).
[e]Some figures are for the fiscal year 68-69, others for the calendar year, 1969. The total does not include grants related to C.N.R. properties for cities other than Montreal. It does not include $1,306,000 paid on properties owned by the Bank of Canada.

APPENDIX 4

FEDERAL ACTIVITIES AND FUNCTIONS INFLUENCING THE QUALITY OF THE PHYSICAL ENVIRONMENT OF URBAN REGIONS

DEPARTMENT	ACTIVITIES									JURISDICTION		
	IN THE CITY						INTER-CITY					
	LAND USE	SPATIAL AREA	HOUSING	URBAN RENEWAL	TRANSPORTATION	RECREATION	POPULATION MOBILITY	COMMUNICATION LINES & TERMINALS	TRANSPORTATION	EXCLUSIVE	SHARED	DEPENDENT OR SPENDING POWER
CENTRAL MORTGAGE & HOUSING CORPORATION	I Q P D $	Q P D $	I Q P D R $	I Q P D $	Q							X
TRANSPORT	Q P D	Q P D	R		Q P D R $		D $	I Q P D R $	I P D R $	X	X	X
NATIONAL HARBOURS BOARD	Q P D R $	Q P D R $		Q P D $	I Q P D R $			I Q P D R $	I Q P D R $	X	X	
CANADIAN NATIONAL RAILWAYS	I Q P D $	I Q P D $	P D $	Q P D $	I Q P D $	I Q P D R $	I Q P D R $	I Q P D $	I Q P D $			X
AIR CANADA	Q P D $				I Q P D $	I Q P D $	I Q P D $	I Q P D $	I Q P D $	X	X	X
CANADIAN TRANSPORTATION COMMISSION	I Q			Q	I Q P D R $	Q	I Q P D $	I Q P	I Q P D R $	X	X	X
PUBLIC WORKS	I Q P D R $	I Q P D R $	P D $	Q P D $	Q P D			Q P D $	P D $		X	
COMMUNICATIONS, POST OFFICE & CDTC	I Q P D $	I	I	I Q P D $	I Q P D	I P D	I	I Q P D R $	I Q P D R $	X	X	X
NATIONAL DEFENCE	I Q P D R $	I	I Q P D R $		I Q P D R $	I P D R $	I Q P D R $	I Q P D R $	I Q P D R $			X
NATIONAL CAPITAL COMMISSION	I Q P D R $	P D		P D $	P D $	I Q P D $		P D $	P D $	X	X	X
REGIONAL ECONOMIC EXPANSION	Q P D $	Q	Q P D $	Q P	Q P D $	Q P	Q P	Q P D $	Q P D $		X	X
INDUSTRY TRADE AND COMMERCE			I Q D $	D	Q D $	Q P D					X	X
MANPOWER & IMMIGRATION		Q	I P D $				I Q P D R $			X	X	
HEALTH & WELFARE			I Q P D $			I Q P D $	R	I Q P D	P D R		X	
ENERGY MINES AND RESOURCES	I Q P		I Q	I Q	I Q	I Q	Q				X	X
NATIONAL ENERGY BOARD	R				R			R	R	X		
DOMINION BUREAU OF STATISTICS			I		I		I Q	I	I	X	X	X
NATIONAL RESEARCH COUNCIL	I Q R		I Q R	I R	I Q D			I Q D	I Q D		X	
SECRETARY OF STATE CITIZENSHIP			I			I Q P D						X
CANADIAN BROADCASTING CORPORATION	P D			P D		I Q P D					X	
CANADIAN RADIO-TELEVISION COMMISSION						Q P D R				X		
FINANCE	P D $	P D $	$	P D $	P D $	$		P D $	P D $	X	X	X

KEY TO FUNCTIONS: INFORMATION SYSTEMS I, RESEARCH Q, PLANNING P, DEVELOPMENT D, REGULATION R, FINANCING $

DEPARTMENT
Includes any agency board commission or corporation set out in schedules to the Financial Administration Act.

INFORMATION SYSTEMS
Systems established for the collection storage analysis and distribution or publishing of data, inventories, advice or ideas, by means of words, sound, print, electronic pulse, etc.

RESEARCH
Includes all types of research whether conducted within public agencies commissioned by them or commissioned by others through grants from public agencies

PLANNING
Presumes the establishment of goals, objectives and policy and includes the creation of plans to be implemented by the department or by others.

DEVELOPMENT
Comprises the implementation and operation of any programmes projects or services and includes construction real estate transactions, etc

REGULATION
Means
1) the making and administering of statutory regulations,
2) the regulatory function as an quasi-judicial body

FINANCING
Includes grants, loans, forgiveness incentives, tax incentives, grants in lieu of tax, cost sharing, transfer payment, etc.

LAND USE
Includes
1) ownership of improved or unimproved land, its maintenance lease or development
2 lease of improved or unimproved land from others
3) advise or regulations that might affect the use of land by others.

SPATIAL AREA
Includes expansion or contraction in the size of the total urban area or of a significant internal sector

HOUSING
Includes single family, detached, row, multiple, apartment, highrise, student, senior citizen, etc., either new, existing or for rehabilitation, subsidized or unsubsidized

URBAN RENEWAL
Includes participation in formal urban renewal schemes under NHA and any activity that involves new construction in or next to the central business district

RECREATION
Leisure time activities including
1) organized and unorganized sports and games, either as a participant or spectator
2) cultural and intellectual pursuits
3 travel
4 hobbies
5 and any other similar activity in which an individual engages in his leisure

[illegible]
Means the movement of any individual or group from any part of Canada to any urban area with the intention of changing domicile

COMMUNICATION LINES
Physical links, including roads, rail, post, waterways, airways, telecommunication lines etc

PEOPLE TRANSPORTATION
Systems for this purpose including the rights of way, terminals, vehicles, tariffs, etc

COMMODITY TRANSPORTATION
Systems for this purpose including the rights of way, terminals, vehicles, tariffs, etc

JURISDICTION
Means the constitutional authority to act and includes statutes, orders in council regulations, and acceptance of the authority of the federal government by another level of government through [illegible]

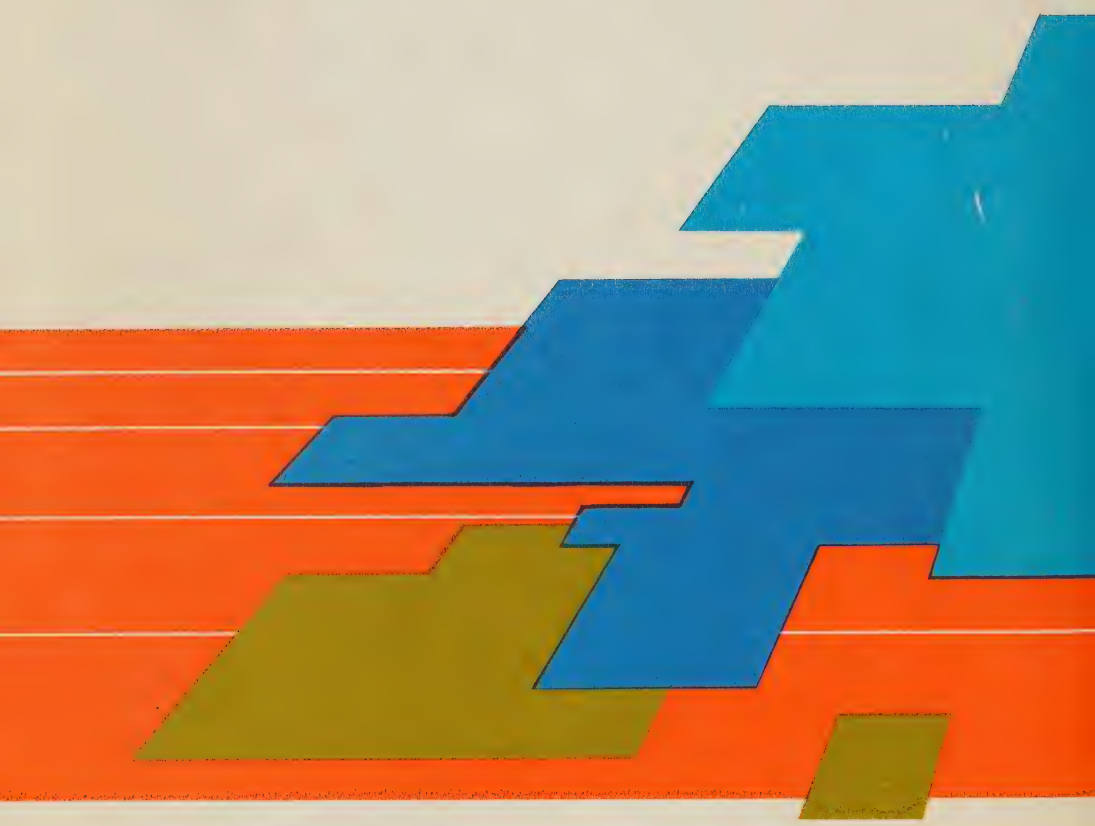
URBAN
Means the thirteen largest Census Metropolitan Areas

VANCOUVER	WINDSOR
EDMONTON	HAMILTON
CALGARY	OTTAWA
REGINA	MONTREAL
WINNIPEG	QUEBEC
WINDSOR	
HALIFAX	

Prepared by P H Aykroyd Privy Council Office, Ottawa March, 1970

APPENDIX 5
CONFIGURATION OF OXIDES OF SULPHUR
METRO TORONTO: 1969

Based on an original map supplied by Air Management Branch, Dept. of Energy and Resources Management, Province of Ontario, 1969.




DEPARTMENT OF
ENERGY, MINES AND RESOURCES
SURVEYS AND MAPPING BRANCH
CANADA
1946
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
GREENLAND
BAFFIN BAY
HUDSON BAY
YUKON TERRITORY
DISTRICT OF MACKENZIE
DISTRICT OF KEEWATIN
DISTRICT OF FRANKLIN
NORTHWEST TERRITORIES
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
UNITED STATES OF AMERICA

Canada. Privy council
[General publications]
[G-3] Environmental
Management